Design And Development of Solar Savvy Auto Light – Working and Energy Efficient

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***Abstract*—The Solar Savvy Autolight is a smart and energy efficient solar off-grid automatic lighting system, equipped with advanced motion and LDR sensor. This ensured that the module charges during day and only turns on during dark and when it senses someone nearby. It is the easiest way to light up public places without grid dependency. Solar Savvy Autolight powered by sun with smart sensors ensure you never waste energy, providing bright automated light which is kind to the planet. This module has a problem-solving approach to stop worrying about leaving the light on, is knows exactly when to brighten up and to dim down (turn off). The assembly states that even using polycrystalline solar panels whose efficiency is less than or up to 15% can also give out working efficiency 228% and energy efficiency up to 57%. By increasing wattage and using of latest solar panels it can give same or better efficient performance.**

***Index Terms*—Solar Off grid, DC voltage, Energy efficient, Work efficient, Automated and smart.**

I. INTRODUCTION

The Solar Savvy AutoLight is a revolutionary lighting solution that harnesses the sun's energy to provide efficient and sustainable illumination. This state-of-the-art system combines renewable energy technology with intelligent automation, significantly reducing dependence on traditional power sources (Grid Dependency) and minimizing environmental impact. By utilizing sunlight, a freely available and renewable resource, the Solar Savvy AutoLight effectively reduces energy consumption and carbon emissions, paving the way for a greener future. Its cutting-edge design makes it perfect for outdoor spaces like streets, gardens, public toilets and campuses, where reliable lighting is crucial. A key highlight of the system is its ability to function independently, even in areas without access to grid electricity, making it an ideal solution for remote locations. With its eco-friendly credentials and versatility, the Solar Savvy AutoLight is poised to replace traditional lighting systems, offering a sustainable and reliable alternative for a brighter future.

II. EXISTING SYSTEM

In the market solar on grid and off grid lights along with only motion sensor or only with LDR sensor or system integrated with both the sensor is available, but the systems are not much energy efficient. In the Design and Development of SolarSavvy Autolight we focused on working and energy efficiency of the system by using electronic component such as LDR sensor, motion sensor, capacitors, voltage regulating circuit, polycrystalline solar panel, ardino nano, batteries and charge controller. The system is fully gridding independent system i.e., off grid system which independently works on charging on sunlight and utilize energy of battery whenever required. We found our product more efficient than the existing systems, introducing Charge control can also optimise better reducing losses.

III. METHODOLOGY

3.1 Working Principle

The SolarSavvy AutoLight system works on a simple idea: it uses sunlight to generate electricity through the photovoltaic effect. In the daytime, the solar panel soaks up sunlight and converts it into DC electricity. This power is not used directly but is stored in a 12V rechargeable battery for later use. Once it gets dark, the battery supplies the stored energy to automatically turn on the LED street light.

3.2 Working Mechanism

The SolarSavvy AutoLight runs on an automatic day-night cycle without needing any manual switching. During the day, the solar panel generates electricity and charges the battery through the charge controller. The LDR light sensor keeps checking the ambient light levels. As long as it's bright outside, the controller keeps the LED switched OFF to avoid wasting power. At night, the LDR detects darkness and activates the system. The PIR motion sensor then starts monitoring for movement nearby. If no one is around, the light stays dim or completely OFF to save battery. But as soon as someone walks by, the system immediately switches the LED to full brightness. After about 30-60 seconds with no further movement, it dims down again. This daily cycle runs completely on its own. Because of this automation, the system is reliable, needs almost no maintenance, and cuts down on electricity bills while still keeping streets well-lit when needed.

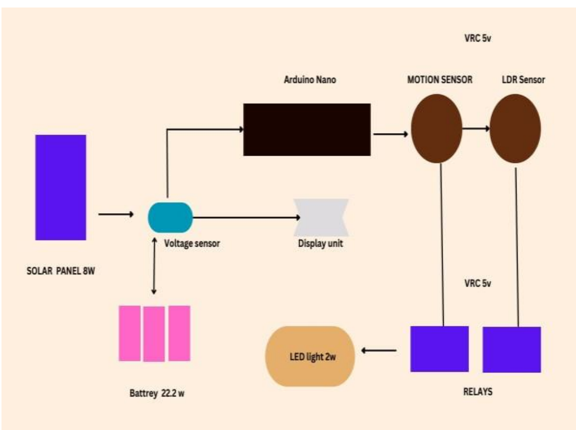

Fig 3.1 Single Line Diagram

3.3 Step-by-Step Working Process

1. Daytime Operation:

The solar panel receives sunlight.

The photovoltaic cells convert sunlight into DC electricity.

The generated electricity charges the battery through the charge controller.

2. Energy Storage:

The battery stores electrical energy throughout the day for later use.

The charge controller manages charging and prevents damage. (24 Volts DC + lighting system)

3. Nighttime Operation:

When sunlight is no longer available, the light sensor detects darkness.

The stored energy in the battery is supplied to the LED lamp.

The light glows until the battery power is depleted or until sunrise.

Fig 3.2 Solar-Powered Automatic LED Light System

Step-by-Step Working Procedure

1. Solar Panel Collects Energy

The solar panel placed in sunlight converts solar energy into DC electricity. In the image, it's placed on the window sill to get maximum sunlight.

2. Battery Charging

This electricity flows into the charge controller circuit on the board. The controller regulates the voltage and charges the 3 lithium-ion batteries safely. You can see the batteries in the pink holder. The LCD shows "Voltage: 10.42V", which is the current battery voltage.

3. Light Detection – LDR Sensor

The LDR sensor at the bottom-left of the board continuously checks the surrounding light level. If it's daytime/bright, the system stays OFF to save power.If it gets dark, the system becomes active and waits for motion.

4. Motion Detection – PIR Sensor

The white dome-shaped PIR sensor detects human motion in its range. When someone walks nearby at night, it sends a signal to the Arduino microcontroller.

5. Automatic Light Control

The Arduino processes the signals from LDR and PIR. If it's dark and motion is detected, it switches ON the

LED strip through the relay. If no motion is detected for some time, it switches OFF again automatically.

6. Power Supply to LED
The LED strip gets power from the charged batteries, not directly from the solar panel. This ensures the light works even at night when there's no sun.
7. Monitoring
The LCD display shows real-time voltage and system status so you can monitor battery health and working condition.

3.4 READINGS
Charging Time – 4hr 30 min
Condition: No environmental light
Discharge cycle Time - Seconds
Motion No motion
LED ON LED OFF

Sr. NO.	Reading 1	Reading 2	Reading 3	Reading 4
1	30	65	55	100
2	35	35	54	58
3	48	45	69	40
4	50	40	88	89
5	33	32	75	66
6	59	39	33	48
7	30	50	35	38
8	30	70	50	30
9	33	74	37	31
10	35	35	38	54
Total	383	485	534	554
Avg	38.3	48.5	53.4	55.4

Sr. NO.	Reading 5	Reading 6	Reading 7	Reading 8
1	90	99	77	95
2	60	95	48	68
3	66	68	58	95
4	95	95	30	97
5	88	97	33	48
6	84	48	65	75
7	85	8	98	33
8	84	58	95	35
9	82	99	92	50
10	90	101	99	69
Total	824	840	695	665
Avg	82.4	84.0	69.5	66.5

Calculating Charging Time
To calculate the charging time, we need to consider the battery's capacity, solar
panel's power output, and charging efficiency.

Given Parameters:
1.Battery: Voltage:
11.1V (3S Li-ion battery) Capacity:

2.Ah (ampere-hours) Solar Panel
Voltage: 12V
Power: 8W

ANALYSIS
Step 1: Calculate the solar panel's
current output Current (A) = Power (W) / Voltage (V)
= 8W / 12V
= 0.67A

Step 2: Calculate the battery's total
Energy (Wh) = Voltage (V) x Capacity (Ah)
= 11.1V x 2Ah
= 22.2 Wh

Step 3: Calculate the charging time
Assuming an ideal charging efficiency of 80% (accounting for losses) and
considering the battery's charging profile: Effective energy required = 22.2 Wh / 0.8 = 27.75 Wh
Charging Time (h) = Effective energy
required / Solar Panel Power
= 27.75 Wh / 8W
= 3.47 hours
However, lithium-ion batteries typically charge in two phases:
constant current (CC) and constant voltage (CV). The CC phase charges the battery to around 80% capacity, and the CV phase charges the remaining 20%.
Practical Estimate: Considering the charging process and potential losses, a more realistic estimate would be: Charging Time ≈ 3.47 hours x 1.2 (accounting for losses and CV phase)
≈ 4.16 hours To charge the battery from 0% to 80%: ≈ 3-3.5 hours
To charge the battery from 0% to 100%: ≈ 4-5 hours

Final Answer:
The 11.1V, 2Ah lithium-ion battery will likely take around 4-5 hours to charge using an 8W, 12V solar

panel under ideal conditions. However, actual charging time may vary depending on sunlight intensity, panel efficiency, and battery health.

Calculating Battery Life: To calculate how long a 22.2Wh battery will power a 2W DC

LED, we can use the following formula: Battery Life (hours) = Battery Capacity (Wh) / Power Consumption (W)

Given:

Battery Capacity: 22.2Wh (calculated from 11.1V x 2Ah)

Power Consumption: 2W

Calculation: Battery Life = 22.2Wh / 2W

= 11.1 hours Practical Estimate: Assuming an efficiency of around 80-90% (accounting for losses), the

actual battery life would be: Battery Life ≈ 11.1 hours x 0.85 (efficiency)

≈ 9.4 hours

Final Answer: The 22.2Wh battery will likely power the 2W DC LED for approximately 9-10

hours, depending on the actual efficiency and battery health.

Calculating Working Efficiency: To calculate the working efficiency, we need to consider the ratio of the battery's discharge time to the charging time. Given: Charging Time: 4.16 hours Discharge Time: 9.5 hours (avg. of 9-10 hours) Working Efficiency: Efficiency = (Discharge Time / Charging Time) x 100

= (9.5 hours / 4.16 hours) x 100

= 228.37%

IV. RESULT

Energy Efficiency:

Energy Out = Discharge Time x Power Consumption

Energy In = Charging Time x Solar Panel Power

Assuming the power consumption is 2W (from the LED) and the solar panel power is 8W:

Energy Out = 9.5 hours x 2W = 19 Wh

Energy In = 4.16 hours x 8W = 33.28 Wh

Energy Efficiency:

Efficiency = (Energy Out / Energy In) x 100

= (19 Wh / 33.28 Wh) x 100

= 57.09%

Actual Working time 7 horse 42 min working

Productive Efficiency = Actual op / Theoretical op

78 % Productive Efficiency

Final Answer:

The working efficiency of the system is approximately 57%, considering the energy input from the solar panel and the energy output to the LED. This efficiency accounts for various losses in the system, including charging and discharging losses.

V. CONCLUSION

The Solar Savvy AutoLight project set out to build a smart street lighting system that runs completely on solar energy, and the final prototype does exactly that. It combines a solar panel, 12V battery, LDR sensor, PIR motion sensor, and Arduino Nano to handle lighting without any manual input. During testing, the system reliably switched the LED light ON only when it was dark and motion was detected nearby. This simple logic made a big difference — it cut down unnecessary power use instead of keeping lights ON all night. The results show that solar-based automatic lighting isn't just a lab concept. It's a workable, low-cost option for streets, pathways, and remote areas where regular grid power is expensive or unavailable. Using it helps lower electricity bills and reduces dependence on conventional energy sources. In short, the project achieved its main goal. Solar Savvy AutoLight proves to be a practical step toward energy-efficient and eco-friendly public lighting.

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