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Hybrid Based (Solar + Wind) Automatic Highway Lighting System

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ABSTRACT:

Energy is a major input for overall socio-economic development of any society. Wind energy is the fastest growing renewable energy. From centuries man has been trying to convert wind power to mechanical & more recently, electric power.Wind technology has improved significantly over the past two decades, and wind energy has become increasingly competitive with other power generation options. Wind power has negligible fuel costs. The solar power is the main source of energy. The solar energy can be converted into electrical energy throughout the day and stored in the battery.

A solar panel is a device that converts the free energy from the sun into more readily usable forms, either absorbing its heat to directly heat water or air or converting its light into electricity. A wind turbine is a device that converts kinetic energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a wind generator or wind charger. So, here we are constructing hybrid solar wind system for the generation of maximum energy. This energy is stored in a 12volts rechargeable battery.In this project the highway lighting system is operated by battery. In this we are using IR Pair and LDR sensors. An Infra-Red (IR) sensor is an electronic device commonly used in security lighting, and burglar alarm systems. When a person in the field of vision of the sensor, the sensor detects the presence and activates highway lighting system.

If it is day time the light gets OFF this operation can be performed by light dependent resistor sensor (LDR).we are having three street lights in this project, one street light will be continuously in on condition based on the LDR sensor. And other two street lights are operated by using IR sensors. his project uses regulated 5V, 500mA power supply. 7805 three terminal voltage regulator is used for voltage regulation. Bridge type full wave rectifier is used to rectify the ac output of secondary of 230/12V step down transformer.

INTRODUCTION:

The solar power is the main source of energy. The solar energy can be converted into electrical energy throughout the day and stored in the battery. A solar panel is a device that converts the free energy from the sun into more readily usable forms, either absorbing its heat to directly heat water or air or converting its light into electricity. A wind turbine is a device that converts kinetic energy from the wind into mechanical energy.

If the mechanical energy is used to produce electricity, the device may be called a wind generator or wind charger. So, here we are constructing hybrid solar wind system for the generation of maximum energy. This energy is stored in a 12volts rechargeable battery.Nowadays, it became essential for people work during nights and returning back to homes late nights, so safety parameter to be implemented to a great extent on highways. This can be best achieved by implementing proper lighting system on highways. The efficient monitoring of this lighting system must be taken into account.

The existing system is like, the high way lights will be monitored manually which in turns is a waste of huge human power as well as precious time in addition with power wastage at the instant when proper monitoring is failed.This drawback can be overcome by implementing a sophisticated automatic monitoring system through which high way lighting can be monitored automatically before the sun sets and they are switched off the next day morning after there is sufficient light on the roads.

But the actual timings for these high way lights to be switched on are when there is absolute darkness. This project gives the best solution for electrical power wastage protection. Also the manual operation of the lighting system is completely eliminated.

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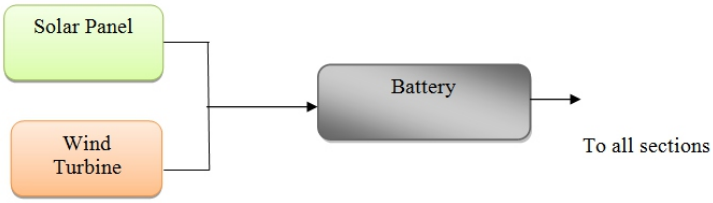
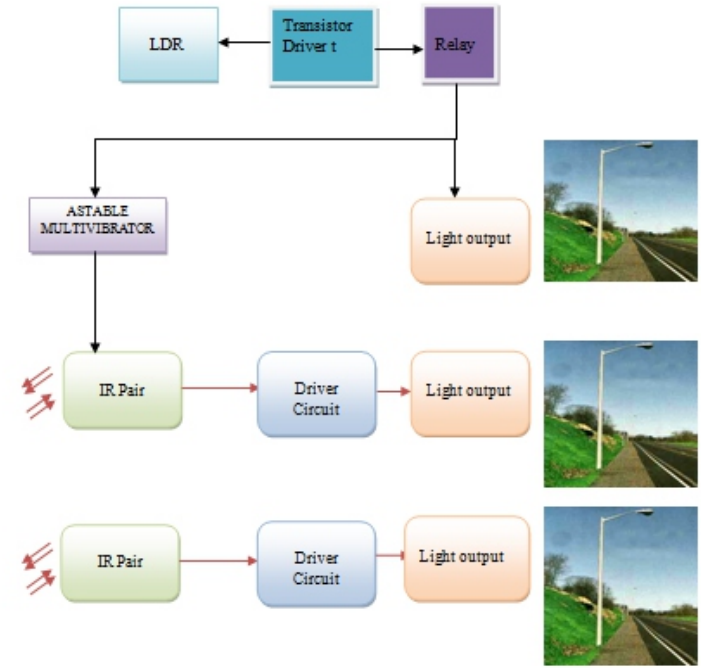
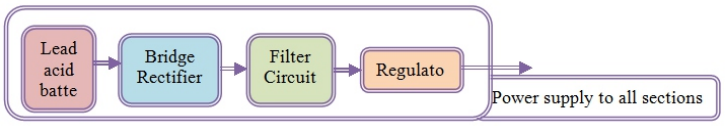




POWER SUPPLY:

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.



FILTER:

Capacitive filter is used in this project. It removes the ripples from the output of rectifier and smoothens the D.C. Output received from this filter is constant until the mains voltage and load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

Voltage Regulator:

As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level.

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In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used.. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation.

WORKING EXPLANATION OF EACH BLOCK:

The internal working procedure involved in this project is explained as follows .The solar panel and wind turbine is going to absorb the light energy and converts it in to Electrical energy. The Electrical energy coming from the Panel is going to be stored in the DC Battery for the future usage. Here we are using LDR in order to switch on the Load in the Night time only. When it is the day time the load connected to the circuit will off mode and saves the Electrical Energy.

There is provided an infrared sensor unit for deactivating an electrical appliance when left unattended by its user. The sensor unit includes a passive infrared sensor for sensing the user through a field of infrared light provided within a viewable distance of the electrical appliance .An Infra-Red (IR) sensor is an electronic device commonly used in security lighting, and burglar alarm systems. When a person in the field of vision of the sensor, the sensor detects the presence and activates highway lighting system, If it is day time the light gets OFF this operation can be performed by light sensor (LDR).Here the street lights turns ON in night time. It stores the energy in day time and utilizes it in night time to switch ON the device.

LIGHT DEPENDENT RESISTOR:

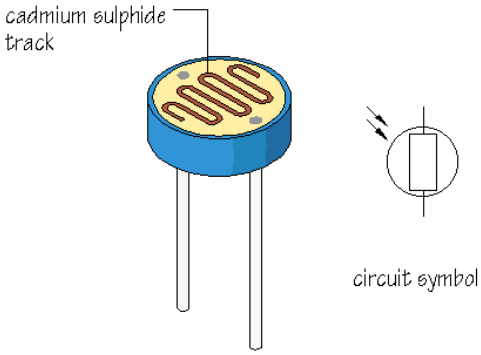
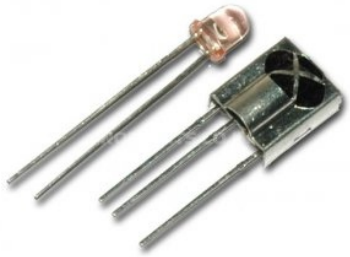


Fig Light dependent resistor

LIGHT DEPENDENT RESISTOR:

LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1,000,000 ohms, but when they are illuminated with light, the resistance drops dramatically.Thus in this project, LDR plays an important role in controlling the electrical appliances based on the intensity of light i.e., if the intensity of light is more (during daytime) the loads will be in off condition. And if the intensity of light is less (during nights), the loads will be switched ON.When the light level is low the resistance of the LDR is low. The current flowing to the base of the transistors. Consequently the LED lights. However, when light shines onto the LDR its resistance is high and it prevents current flows into the base of the transistor. The LED does not light.

IR TRANSMITTER AND RECEIVER:



WHAT IS INFRARED?

Infrared is a energy radiation with a frequency below our eyes sensitivity, so we cannot see it .Even that we can not "see" sound frequencies, we know that it exist, we can listen them.

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IR TRANSMITTER:

The IR LED emitting infrared light is put on in the transmitting unit. To generate IR signal, 555 IC based astable multivibrator is used. Infrared LED is driven through transistor BC 548.IC 555 is used to construct astable multivibrator which has two quasi-stable states. It generates a square wave of frequency 38 kHz and amplitude 5Volts. It is required to switch 'ON' the IR LED.

Photo:

IR reflectance sensors contain a matched infrared transmitter and infrared receiver pair. These devices work by measuring the amount of light that is reflected into the receiver. Because the receiver also responds to ambient light, the device works best when well shielded from ambient light, and when the distance between the sensor and the reflective surface is small(less than 5mm).

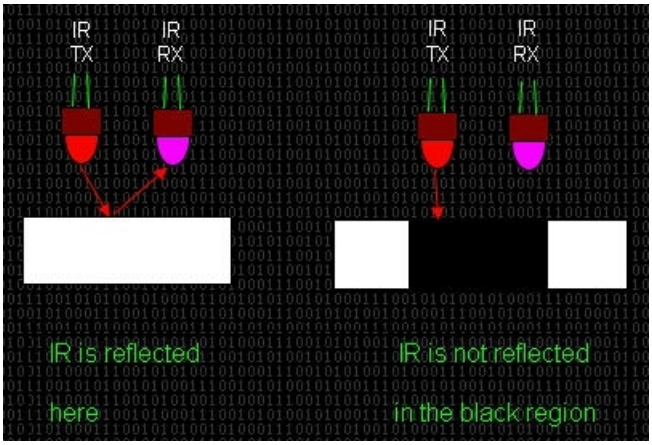

Fig. Schematic Diagram for Single Pair of Infrared Transmitter and Receiver.

IR reflectance sensors are often used to detect white and black surfaces. White surfaces generally reflect well, while black surfaces reflect poorly. One of such applications is the line follower of a robot.

RELAYS:

A relay is an electrically controllable switch widely used in industrial controls, automobiles and appliances.

The relay allows the isolation of two separate sections of a system with two different voltage sources i.e., a small amount of voltage/current on one side can handle a large amount of voltage/current on the other side but there is no chance that these two voltages mix up.

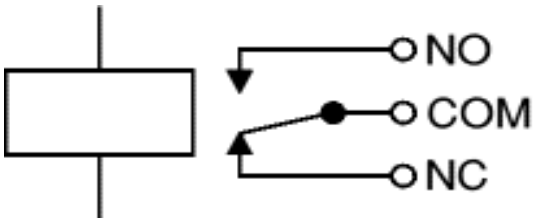

Fig:.Circuit symbol of a relay

SOLAR CELL DESCRIPTION:

Fig Solar panel

INTRODUCTION:

In Today's world global warming is being increasing year by year. There are many reasons like pollution, deforestation, water contamination, etc.... Here we are designing a hybrid based highway lighting system which is cheaper as well as eco-friendly.

How a Photovoltaic Cell Works:
Step 1:

A slab (or wafer) of pure silicon is used to make a PV cell. The top of the slab is very thinly diffused with an "n" dopant such as phosphorous. On the base of the slab a small amount of a "p" dopant, typically boron, is diffused. The boron side of the slab is 1,000 times thicker than the phosphorous side. Dopants are similar in atomic structure to the primary material. The phosphorous has one more electron in its outer shell than silicon, and the boron has one less. These dopants help create the electric field that motivates the energetic electrons out of the cell created when light strikes the PV cell. The phosphorous gives the wafer of silicon an excess of free electrons; it has a negative character.

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This is called the n-type silicon (n = negative). The n-type silicon is not charged—it has an equal number of protons and electrons—but some of the electrons are not held tightly to the atoms. They are free to move to different locations within the layer. The boron gives the base of the silicon a positive character, because it has a tendency to attract electrons. The base of the silicon is called p-type silicon (p = positive). The p-type silicon has an equal number of protons and electrons; it has a positive character but not a positive charge.

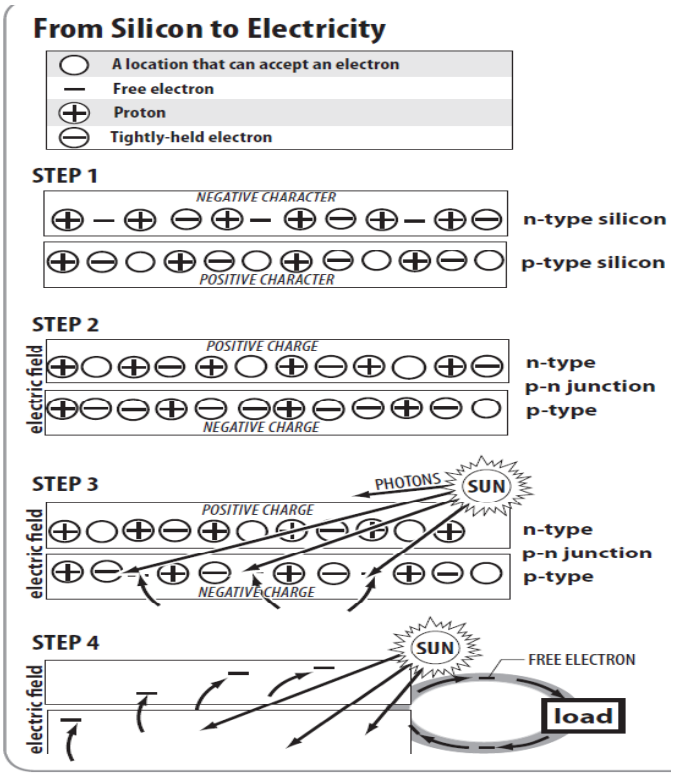

Fig .Working of photovoltaic cell

Step 2:

Where the n-type silicon and p-type silicon meet, free electrons from the n-layer flow into the p-layer for a split second, then form a barrier to prevent more electrons from moving between the two sides. This point of contact and barrier is called the p-n junction. When both sides of the silicon slab are doped, there is a negative charge in the p-type section of the junction and a positive charge in the n-type section of the junction due to movement of the electrons and "holes" at the junction of the two types of materials. This imbalance in electrical charge at the p-n junction produces an electric field between the p-type and n-type silicon.

Step 3:

If the PV cell is placed in the sun, photons of light strike the electrons in the p-n junction and energize them, knocking them free of their atoms. These electrons are attracted to the positive charge in the n-type silicon and repelled by the negative charge in the p-type silicon. Most photon-electron collisions actually occur in the silicon base.

Step 4:

A conducting wire connects the p-type silicon to an electrical load, such as a light or battery, and then back to the n-type silicon, forming a complete circuit. As the free electrons are pushed into the n-type silicon they repel each other because they are of like charge. The wire provides a path for the electrons to move away from each other. This flow of electrons is an electric current that travels through the circuit from the n-type to the p-type silicon. In addition to the semi-conducting materials, solar cells consist of a top metallic grid or other electrical contact to collect electrons from the semi-conductor and transfer them to the external load, and a back contact layer to complete the electrical circuit.

WIND TURBINE:

Wind turbine blades are shaped to generate the maximum power from the wind at the minimum cost. Primarily the design is driven by the aerodynamic requirements, but economics mean that the blade shape is a compromise to keep the cost of construction reasonable. In particular, the blade tends to be thicker than the aerodynamic optimum close to the root, where the stresses due to bending are greatest. The blade design process starts with a "best guess" compromise between aerodynamic and structural efficiency.

Fig Aero Wind Blade

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How blades capture wind power:

The lift force increases as the blade is turned to present itself at a greater angle to the wind. This is called the angle of attack. At very large angles of attack the blade "stalls" and the lift decreases again. So there is an optimum angle of attack to generate the maximum l if .Lift & drag vectors. There is, unfortunately, also a retarding force on the blade the drag. This is the force parallel to the wind flow, and also increases with angle of attack. If the aerofoil shape is good, the lift force is much bigger than the drag, but at very high angles of attack, especially when the blade stalls, the drag increases dramatically. So at an angle slightly less than the maximum lift angle, the blade reaches its maximum lift/drag ratio. The best operating point will be between these two angles. Since the drag is in the downwind direction, it may seem that it wouldn't matter for a wind turbine as the drag would be parallel to the turbine axis, so wouldn't slow the rotor down. It would just create "thrust", the force that acts parallel to the turbine axis hence has no tendency to speed up or slow down the rotor. When the rotor is stationary (e.g. just before start-up), this is indeed the case. However the blade's own movement through the air means that, as far as the blade is concerned, the wind is blowing from a different angle. This is called apparent wind. The apparent wind is stronger than the true wind but its angle is less it rotates the angles of the lift and drag to reduce the effect of lift force pulling the blade round and increase the effect of drag slowing it down. It also means that the lift force contributes to the thrust on the rotor. The result of this is that, to maintain a good angle of attack, the blade must be turned further from the true wind angle.

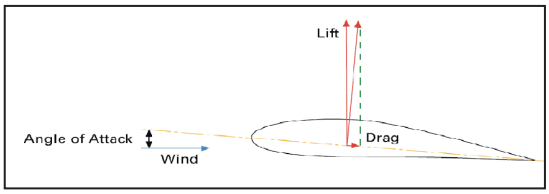

Fig. Angle of attack of wind

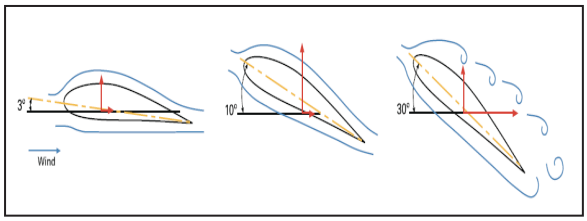

Fig.Angle of wind blow

THE POWER IN THE WIND:

Wind possesses energy by virtue of its motion. Any device capable of slowing down the mass of moving air, like a sail or propeller, can extract part of the energy and convert is into useful work. Three factors determine the output from a wind energy converter.

i.The wind speed

ii.The cross-section of wind swept by rotor; and

iii. The overall conversion efficiency of the rotor, transmission system and generator of pump.

No device, however well-designed, can extract all of the wind's energy because the wind would have to be brought to a halt and this would prevent the passage of more air through the rotor. The most that intercepted air to about one-third of its free velocity. A 100% efficient aero generator would therefore only be able to convert up to mechanical energy. Well-designed blades will typically extract 60% of the theoretical maximum, but losses incurred in the gearbox, transmission system and generator or pump could decrease overall wind turbine efficiency to 35% or loss.

$$m = pAV \quad (1)$$

Where,

m= Mass of air transverse

A= Area swept by the rotating blades of a wind mill type generator .

Substituting this value of the mass in the expression for the kinetic energy, we obtain,

Kinetic energy = 1/2pAV.V2 watts…….(2)

Equation above tells us that the maximum wind available the actual amount will be somewhat less because all the available energy is not extractable is proportional to the cube of the wind speed.

Since the area is normally circular of diameter D in horizontal axis aero turbines, then A=π/4D2, (sq.m), which when put in equation gives,

Available wind power pa=1/2 p π/4D2V3watts

=1/8 pD2V3 …….. (3)

D = Diameter of horizontal axis aero turbine.

The equation tells us that the maximum power available from the wind varies according to the square of the diameter of the intercept area (or square of the rotor diameter), normally taken to be swept area of the aero turbine.

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Power coefficient:

The ideal, or maximum, theoretical efficiency ηmax (also called the power coefficient) of a wind turbine is the ratio of the maximum power obtained from the wind, to the total power a available in the wind. The factor 0.593 is known as the Betz coefficient fraction of the power in a wind stream that can be extract.
Power coefficient (Cp) = power output from wind machine/power available in wind
= 0.593

CALCULATIONS

15.1 SPECIFICATIONS OF SOLAR PANEL:

Length of the solar panel (l) = 0.45 m
= 45 cm
Width of the solar panel (w) = 0.30m
= 30 cm
Thickness (t) = 0.015 m
= 1.5 cm
Rated power of the solar panel (pr) = 5 watts
Area of the solar panel (A) = length*width
= 0.45*0.30
= 0.135 sq.m
Peak power obtained from the soalr panel (pe) = 3.1 watts(approximately)

Efficiency of the solar panel = Peak power of the panel / area of the solar panel
= 3.1/0.135
= 0.2296 or
= 22.96%

SPECIFICATIONS OF WIND TURBINE

Sweap radius (r) = 0.09 m
= 9 cm
Length of the blade (l) = 0.07 m
= 7 cm
Thickness of the blade (t) = 2 mm
Number of blades (n) = 3
Radius of the rotor = 0.02 m
= 2 cm
Air density = 1.41 kg/m3
Power coefficient (cp) = 0.58
Available wind power (A.p) = π/8 pD2V3 watts.

Swept area (A) = π/4D2 sq.m
or πr2 sq.m
= π/4*0.18 = 254 sq.cm
= 0.0254 sq.m
Let us consider Wind velocity (V) = 8 m/s
Available wind power (p) = 1.41*(0.18)2*(8)3
Available wind power = 9.18 watts

ADVANTAGES:

- Power saving
- Absence of moving parts
- Modular nature in which desired currents,voltages and power levels can be achieved by mere integration.
- Fit and forget system
- Maintenance cost is low as they are easy to operate.
- They do not create pollution.
- They have long effective of life.
- They are highly reliable.
- They consume no fuel to operate as the sun's energy is free.

APPLICATIONS:

- Public Areas
- Highway Lighting System
- This is mainly designed, to apply this in real time power saving applications in street lights, to reduce power consumption unnecessarily.
- Real time application.
- Railway track signals.

Fig Hybrid energy

CONCLUSION:

The project "Hybrid based automatic highway lighting system with day/night sensor." is successfully tested and implemented.

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By using this project in real time applications we can reduce the wastage of power. No need of human effort to switch ON or OFF the street-lights. By using the solar wind energy we can drive street lights which are cost effective.

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