ANJUMAN - I - ISLAM'S KALSEKAR TECHNICAL CAMPUS, NEW PANVEL

A Report on

SOLAR STREETS LIGHT WITH AUTO INTENSITY CONTROLLER.

DEPARTMENT OF ELECTRICAL ENGINEERING

UNDER THE GUIDANCE OF

PROF. RIZWAN FARADE

2020-2021

AFFILIATED TO

UNIVERSITY OF MUMBAI

A PROJECT REPORT
ON
"SOLAR STREETS LIGHT WITH AUTO INTENSITY CONTROLLER."

Submitted to DEPARTMENT OF ELECTRICAL ENGINEERING.
In Partial Fulfilment of the Requirement for the Award of

BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING BY

MAPARI ZAID	17EE14
SHAIKH MOHAMMAD AAFAQUE	17EE19
SHAH SHAHBAAZ	15EE35
BANKER JUNAID	17EE06

UNDER THE GUIDANCE OF

PROF. RIZWAN FARADE.

DEPARTMENT OF ELECTRICAL ENGINEERING

Anjuman-I-Islam's Kalsekar Technical Campus
SCHOOL OF ENGINEERING & TECHNOLOGY
Plot No.23, Sector-16, Near Thana Naka, Khandagaon,
New Panvel-410206 2020-2021

CERTIFICATE

This is to certify that the project entitled

"SOLAR STREETS LIGHT WITH AUTO INTENSITY CONTROLLER."

Submitted by,

MAPARI ZAID	17EE14
SHAIKH MOHAMMAD AAFAQUE	17EE19
SHAH SHAHBAAZ	15EE35
BANKER JUNAID	17EE06

Is a record of bonafide work carried out by them, in the partial fulfilment of the requirement for the award of Degree of Bachelor of Engineering (Electrical Engineering) at ***Anjuman-I-Islam' Kalsekar Technical Campus, New Panvel*** under the University of MUMBAI. This work is done during year 2020-2021, under our guidance.

Date: / /

(Prof. RIZWAN FARADE)
Project Guide

(Prof. RIZWAN FARADE)
HOD, Electrical Department

DR. ABDUL RAZAK HONNUTAGI
Director A.I.K.T.C.

External Examiner

ACKNOWLEDGEMENTS

We would like to take the opportunity to express our sincere

thanks to our guide Mr. RIZWAN FARADE, Head of Department Of Electrical Engineering, AIKTC, School of Engineering, Panvel for his in valuable support and guidance throughout my project research work. Without his kind guidance & support this was not possible.

We are grateful to him for his timely feedback which helped us track and schedule the process effectively.

His time, ideas and encouragement that he gave, helped us to complete our project efficiently.

We would like to expressed appreciation towards

DR. ABDULRAZAK HONNUTAGI, Director, AIKTC, Navi Mumbai, Prof. Rizwan Farade, Head of Department of Electrical Engineering and our Project Coordinator too whose in valuable guidance supported us in completing this project.

At last we must express our sincere heart felt gratitude to all the staff members of Electrical Engineering Department who helped us directly or indirectly during this course of work.

MAPARI ZAID
SHAIKH MOHAMMAD AAFAQUE
SHAH SHAHBAAZ
BANKER JUNAID

PREFACE

We are glad to present our project entitled

"SOLAR STREETS LIGHT WITH AUTO INTENSITY CONTROLLER."

The main objective of this report is to provide a better solution to minimize electrical wastage in operating street lights. Manual control of street lights is error prone and leads to significant wastage of energy.

Manually dimming of street lights during night hours is also not practically possible. A rapid advancement in embedded systems technology has paved the path for virtual mechanisms based on microcontrollers.

A programmable micro controller of 8051 family is engaged to provide different intensities using PWM technique using a charge controller for battery charging overload and deep discharge protection.
Energy efficient technologies and design mechanism can reduce the cost of street lighting drastically.

.

ABSTRACT

The project is designed for LED based street lights with an auto intensity control that uses solar power from photovoltaic cells.
A charge controller circuit is used to control the charging of the battery, and an LDR is used to sense the ambient light on day time.
We have also at-tempted to measure the solar cell parameters through multiple sensor data acquisition.

In this system, different parameters of the solar panel like light intensity, voltage, current and temperature are monitored using a microcontroller of the PIC16F8 family. The intensity of street lights is required to be kept high during the peak hours. The street lights are switched on at the dusk and then switched off at the dawn automatically by using a sensing device LDR LED lights are the future of lighting, because of their low energy consumption and long life they are fast replacing conventional lights world over. White light emitting diode (LED) replaces the HID lamps where intensity control is possible by pulse width modulation. A programmable microcontroller of the 8051 family is engaged to provide different intensities at different times of the night using PWM technique, for energy saving for solar based system, also using a charge controller for protecting the battery from over charging, overload and deep discharge protection.

A light sensing device LDR (Light Dependent Resistance) is used whose resistance reduces drastically in day light for sensing purposes. In the measuring circuit the light intensity is monitored using an LDR sensor, the voltage by voltage divider principle, the current by current sensor and the temperature by temperature sensor.

INDEX

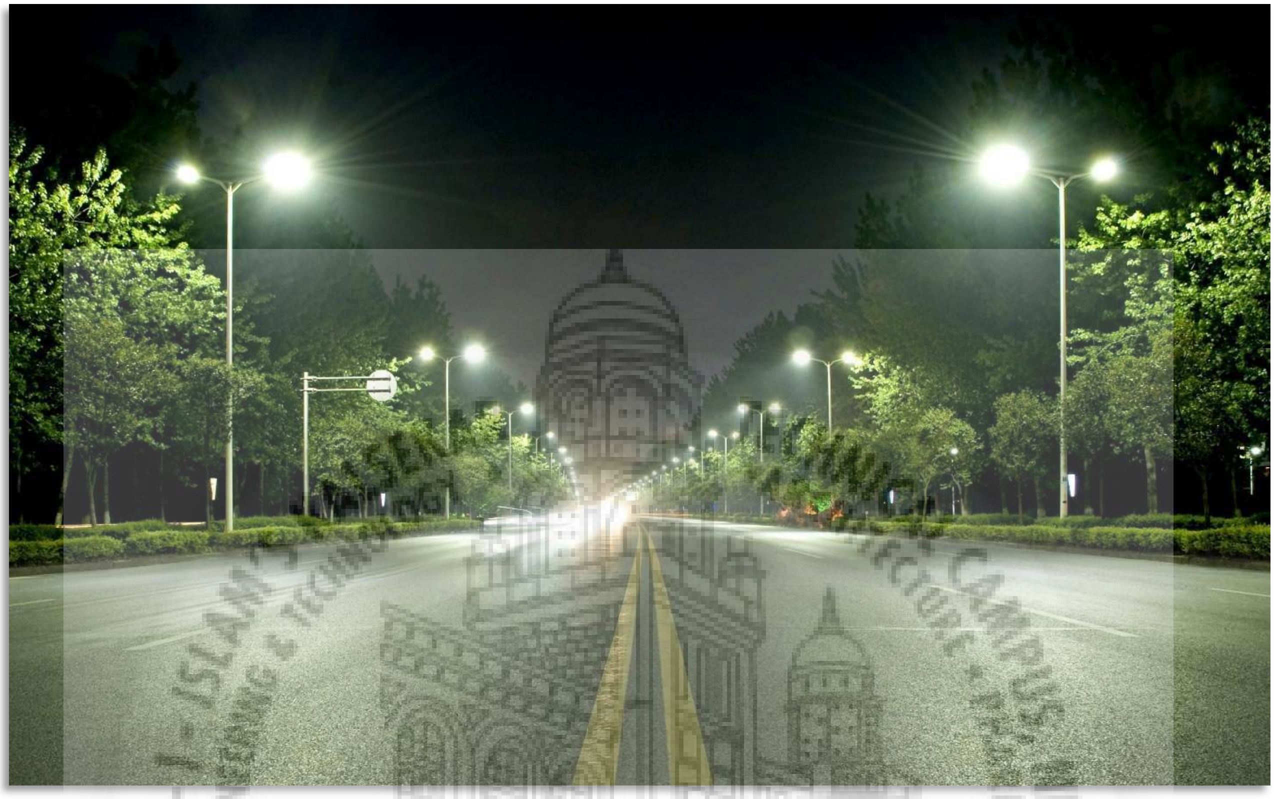
INTRODUCTION

The main consideration in the present field technologies are Automation, Power consumption and cost effectiveness. Providing street lighting is one of the most important and expensive responsibilities of a city. Energy efficient technologies and design mechanism can reduce cost of the street lighting drastically. There are various numbers of control strategy and methods in controlling the street light system to ensure that it consumes less energy and is efficient in terms of money and usage.

Another way is to exploit the new energy-saving technologies to reduce energy consumption, and improve utilization efficiency of energy. Solar energy is the most direct, common, and clean energy on our planet we have already found until now. Total solar energy absorbed by the Earth is about 3,850,000 exajoules (EJ) in one year, which is even twice as much as all the non-renewable resources on the earth found and used by human being, including coal, oil, natural gas, and uranium etc.

The solar resources can be seemed inexhaustible. LED is a solid state semiconductor device which can convert electrical energy into visible light. It is characterized with small size, low power consumption, long service life, environmental protection and durance. The spectrum of the LED is almostly concentrated in the visible light spectrum, so it has a high luminous efficiency which can be described as the great reform in the solid light source.

This essay briefly describes the solar led street lighting system. It uses the solar radiation energy to charge the battery with the solar panel during day time, and offer energy to the LED light equipment at night. This system has a double advantage in both utilization of new energy and energy-saving.



Chapter 1

Solar LED Street Light

1.1 Requirements on solar LED street light and significance of design

The solar street light does not need to set up the transmission line or route the cable, and no any special management and control are required. It can be installed in the entire public place such as the square, the parking lot, the campus, the street or the highway etc. The street lighting is closely related to people's daily life. Following quick development in process of the global urbanization, the green, efficient, and long-life LED light gradually enters into our lives.

A good LED street lighting system is characterized with high efficiency, energy-saving, long-life, high color rendering index and environmental protection, which not only has a great significance on energy-saving of the city lighting, but also has close relationship with people's health and the economic development. So it is a noticeable issue how to design a reasonable LED street light system.

In my opinion, following basic requirements on a qualified solar LED street light system shall met during design process:

(1) Learn general information of the meteorological conditions in the area.

(2) Select the cost-effective solar panel, the controller, the battery and a series of components.

(3) Adopt effective measures to protect the system. These conditions ensure to design a reasonable solution and realize the significance and value of the existence of solar LED Street Light Street

1.2 Overview Of Solar LED Street Light

1.2.1 Hardware Specifications

As shown in Figure 1.2.1.

The system consists of:

1. Crystal Oscillator
2. Capacitor
3. Cables and Connector
4. PCB and Breadboard
5. Transformer/Adapter
6. Switch
7. IC Sockets
8. Solar Panel
09. Resistors
10. Transistor
11. Diodes
12. LED
13. Push Buttons
14. IC
15. Battery

Figure 1.2.1

1.2.2 Operation principle

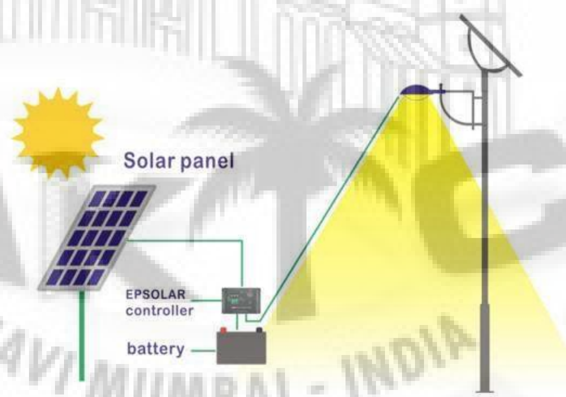


Fig. 1.2.2 Operation principle

If we can make the function of each part in Fig.1.2.2 abstractly, we can get the system workflow (Fig.1.2.3)

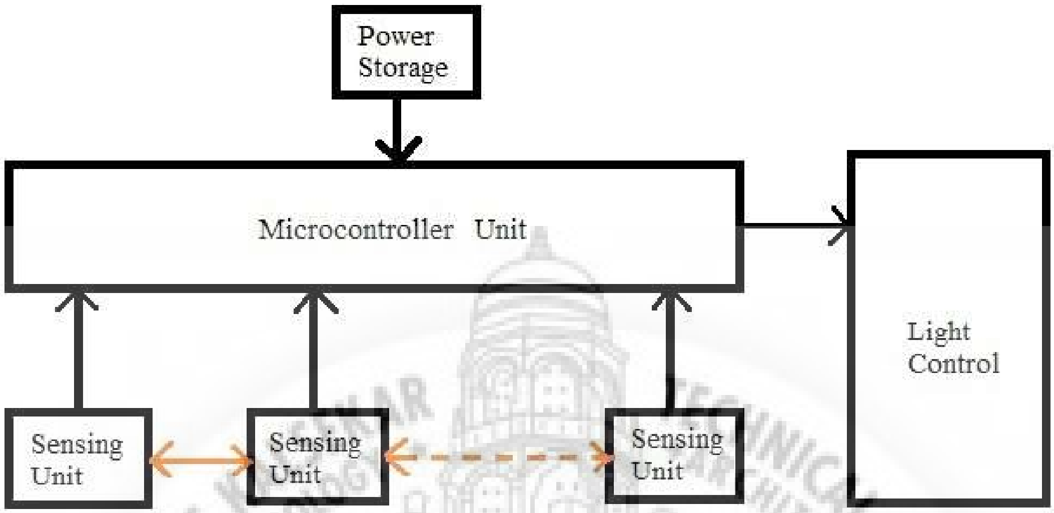


Fig. 1.2.3 System workflow

According to principle of photovoltaic effect, the solar panels receive solar radiation during the day time and then convert it into electrical energy through the charge and discharge controller, which is finally stored in the battery. When the light intensity reduced to about 10 lx during night and open circuit voltage of the solar panels reaches at a certain value, the controller has detected voltage value and then act, the Battery offer the energy to the LED light to drive the LED emits visible light at a certain direction. Battery discharges after certain time passes, the charge and discharge controller will act again to end the discharging of the battery in order to prepare next charging or discharging again.

1.3 Current situation and Development.

From the current situation of the LED, there are still many problems which shall be further improved. For example, the quality of the LED chip, heating problem, package problem, power driver issue and the lifetime of the electronic components. LED lighting is a developing technology although its luminous efficiency is improving and cost is continuously reduced, but it still needs long time to completely replace the traditional high pressure sodium street lighting. Following progressing of the technology, the LED lights can use more low-power6 products to achieve same effect as the traditional lighting, and the price will decreased significantly in the coming year. The significant progress of the LED must make it completely replace the traditional street lights. The LED has a bright future.

Chapter 2

Device in solar LED street light system The solar street lighting system consists of many sections. In this chapter, only the Solar panel, the Battery, the Controller and the Led lights are briefly introduced.

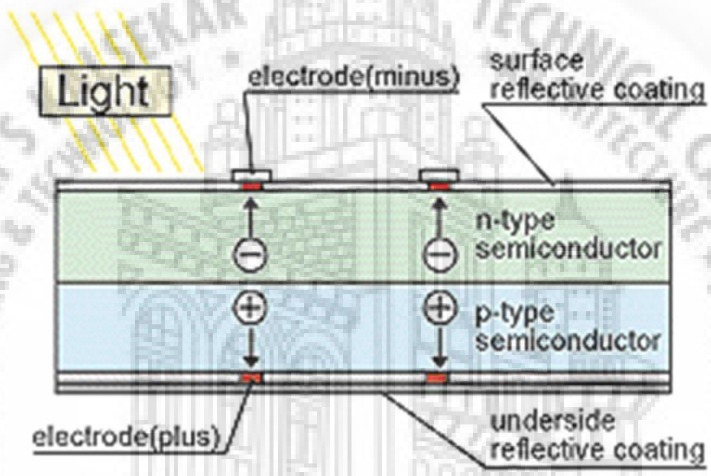
2.1 Solar panel.

2.1.1 Working principle

The Photovoltaic (PV) cell is composed of at least two layers of the semiconductors which have been "doped" with different impurities. This makes an excess of free electrons (n-type) on one side of the junction, and a lack of free electrons (p-type) on another side.

When the photovoltaic cells are irradiated with sunlight, some photons are reflected and the others are absorbed by the solar cell. When the photovoltaic cells keep enough photons, the negative electrons are released from the semiconductor material. Due to the manufacturing process of the positive layer, these free electrons naturally migrate to the positive layer which creates voltage differential.

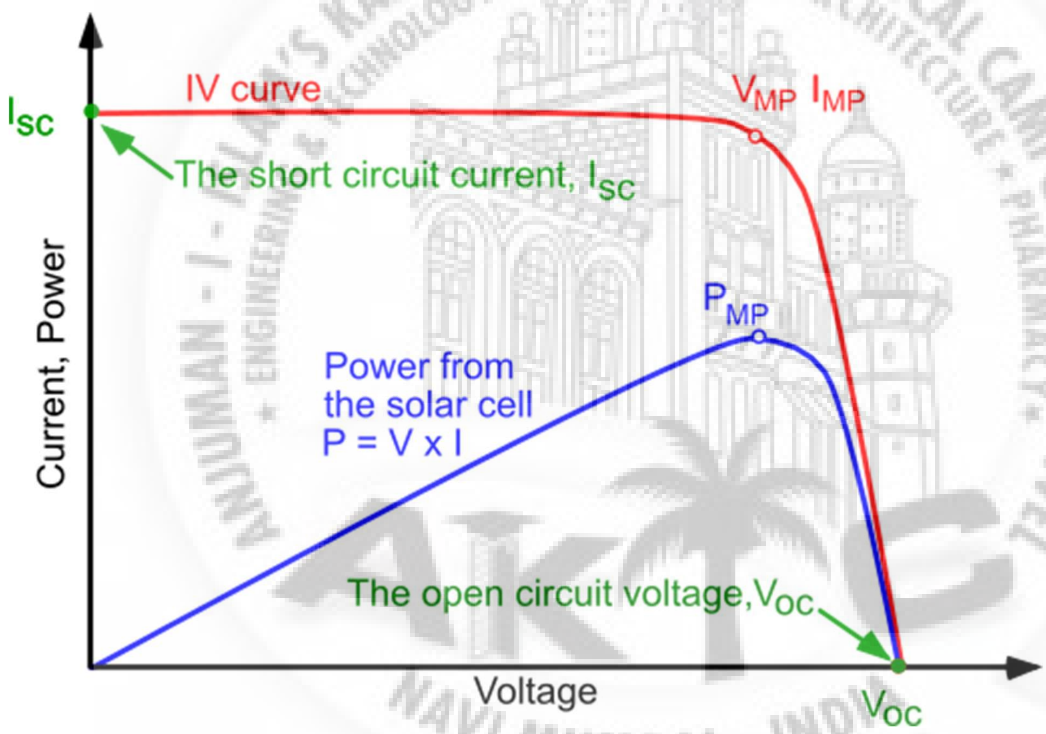
When the solar cell is connected with the external load, there will be a current circulation in the circuit. Each single solar energy cell produces only 1-2 watts. In order to increase output power, these cells (from one to several thousands) are connected in series or in parallel with others, what is called a solar array



(PRINCIPLE OF SOLAR CELL)

2.1.2 V-I Characteristic of Solar Cell

Fig. 2.1.2 shows the V-I characteristic curve and output power of a solar panel. The curve has two parts, one indicates the trend of current with respect to increasing voltage. The other curve is the power-voltage curve and is obtained by the equation P=V*I. If no load is connected with the solar panel which is working in sun light, an open-circuit voltage Voc will be produced but no current follows. If the terminals of the solar panel are shorted together, the short-circuit current ISC will flow but the output voltage will be zero. In both cases, when a load is connected, we need to consider V-I curve of the panel and V-I curve of the load to find out how much power can be transmitted to the load. The maximum power point (MPP) is the spot near the knee of the V-I curve, and the voltage and current at the MPP are designated as Vm and Im. For a particular load, the maximum point is varying following insolation, shading and temperature. It is important to operate panels at their maximum power conditions.



2.1.3 Selection of solar panels

The solar panel is the core part of the solar street light system which converts the sun's radiant energy to electrical energy, and then transmits through the controller to be stored in the battery.

In sunny areas, the Polycrystalline silicon solar cell is more appropriate, because the price of the Polycrystalline silicon solar cells is lower than the Monocrystal silicon solar cells. But in the more-rainy-days areas where sunlight is relatively not very adequate; it is better to choose the Monocrystalline silicon solar cells, because the optical conversion efficiency of the monocrystalline silicon solar cells is higher.

2.1.4 Power of solar panels

Output power of the solar panel is random, it means output power is different at different time and places for the same piece of the solar panels. So we should consider not only the intensity of the local average solar radiation but also the daily working10 hours and the power of lighting lamp during calculation of the solar panel power.

The solar panel power can be calculated with the following equation…

$P(pv) = (1/\ \eta_1\ \eta_2) * ((P_{LED} * h_{LED}) / h_{(pv)}) * K$……….(2.1.3)

Where:

η_1…………………Charging efficiency of the battery

η_2…………………Efficiency of the LED driver circuit

PLED……….........Power consumption of the LED (W)

hLED………………Daily lighted time of Lamps (h) h(pv)………………Average of daily peak sunshine hours

k……………………Loss coefficient of solar panel (for example, Dust obscured)

2.1.5 Installation of solar panel.

The azimuth angle of the square solar cells is the angle of south direction and Vertical plane of the square, which is the direction during installation of the solar panels. In general, efficiency of the solar cell is highest when the square faces south (i.e. azimuth angle of 0 °). The declining angle is the angle between the surface of the solar cell and the horizontal plane which is the best declining angle that the square can make the maximum generating capacity per year. The optimum declining angle is related to the local latitude and with the raise of the latitude, the inclination will also increase.11 However, we should also take into account of some limiting conditions at the same of azimuth, just like the declining angle of the roof and the snow sliding. In one word, the best angle will make the daily power output reach maximum value.

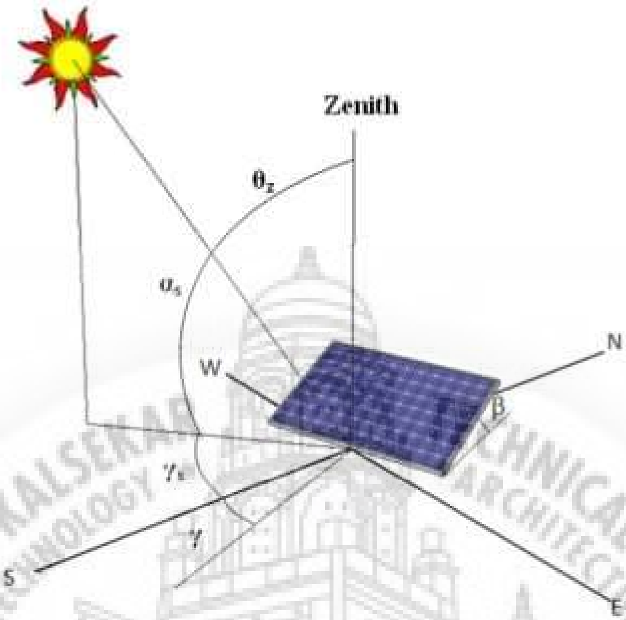


Fig. 2.1.4 Solar angles used in power calculations for PV panels.

In the Fig. 2.1.4, γ is Surface Azimuth Angle, β is Collector Slope,

All described above are the relationship between the azimuth angle, the declining angle and the power generation amount. For the particular design of a square, we should consider all-around according to actual situations.

Furthermore, when a multi-block square solar cells is arranged, we should pay attention to impact of shadow which will decrease the generation capacity of 10% to 20%. So during arrangement of the every single square, we need adjust height to the optimum state. In snowy areas, the inclining angle of snow fall also cannot be ignored. If the optimum declining angle conflicts with the declining angle of snow, we should follow the program which can generate more electricity.

2.2 Battery

2.2.1 Selection of Battery.

The requirements of the battery on the solar street light is: slower discharge rate and the long discharge time, it was decided that we usually chose the large-capacity lead-acid batteries, thus the high-energy and maintenance free valve-regulated lead-acid batteries (VRLA) is a better choice. The VRLA battery has a one-way exhaust valve (also called a valve-regulated cap) on the battery cover which can vent surplus gas in case of unusual circumstances.

The so called "maintenance-free " is regularly compared with maintenance of the traditional lead-acid battery. The VRLA batteries do not require adding water or acid during service life and it is not necessary to check the electrolyte level.

In addition, the standard to measure the quality of battery is reflected as the following aspects:

i Long life as long as life of the system.

ii High reserve capacity and high capacity retention rate, in order to meet
the lighting needs in the consecutive rainy period.

iii High charge acceptance efficiency which can maximize output power of the solar cell, and also shorten the charging time.

iv Good sealing performance, no acid or gas leakage, so the battery can be set with controller.

v Wide working temperature range (- 20°C to 50°C) vi Good discharge performance

The quality of the battery is directly related to performance of the streetlights.

Now there is a lot of supporting battery products on the market which are designed for the solar lighting system, we should find the appropriate battery through comparing and testing.

2.2.2 Capacity calculation of battery.

The batteries are the main components in the solar LED street lights system, they can store energy which are generated by the solar cell during day time, and meet the power consumption of lighting at night and lighting needs in consecutive rainy days. It is not possible to meet the needs of night lighting if the battery capacity is too small. Inversely If the battery capacity is too large, we need a large solar panels to ensure the battery is fully charged in a limited time during the day. The overlarge panels and battery will cause increasing of cost and also the waste. If the solar panel is not large enough, the battery cannot be fully charged in limited period of time during the day, it will always be in a state of power deficit, this is a bad effect of the battery life.

The capacity of the battery can be calculated by the following formula.

$$C = ((Q*(D+1)) / ((K1*(1-K2))) \ldots\ldots\ldots\ldots (2.2.1)$$

In the formula

C………Standard capacity of the battery.
Q………Power consumption per day of the lamps.
D………Maximum number of continuous rainy days.
k1……...Depth of discharge(DOD), generally the DOD of VRLA is 0.75.
k2……...Loss electricity of the battery's self-discharge.(10%)

2.2.3 Precautions on battery

The batteries cannot be directly connected in parallel, because the battery's internal resistance is different and it will form a circulation inside the batteries. So it is better to be connected in series. Moreover, a fuse must be set to protect the battery. It is also necessary to consider local weather conditions in case of excessive rainfall and in order to avoid flooding

2.3 Controller

The controller is the intelligent core of the whole solar streetlight system, it controls the entire system's normal operation and automatically prevents the battery's overcharge, or over discharge. Its basic functions must also have light control, time control and antireverse connection etc. The controller generally has a simple measurement function. We use the DC chopper as the main circuit and the single-chip or the low-power integrated circuits as the control circuit.

2.3.1 Main Circuit Type

Currently the mainly circuit topology has Step-down(Buck) converter, Step-up (Boost) converter and Cuk converter.

I Buck(Step-down) converter.

The Buck converter is also known as the Step-down chopper circuit. Its principle is shown in Fig. 2.3.1(a). It has two basic operating modes. That is Continuous Current Mode(CCM) and Discontinuous Current Mode(DCM).

In CCM the output current is always greater than zero. In DCM, output current is zero in a period of time when the switch is turned off, it is a critical state between these two states, that is the current which is exactly zero at end of the switch off period. The equivalent circuit of each15 state is shown in Fig 2.3.1

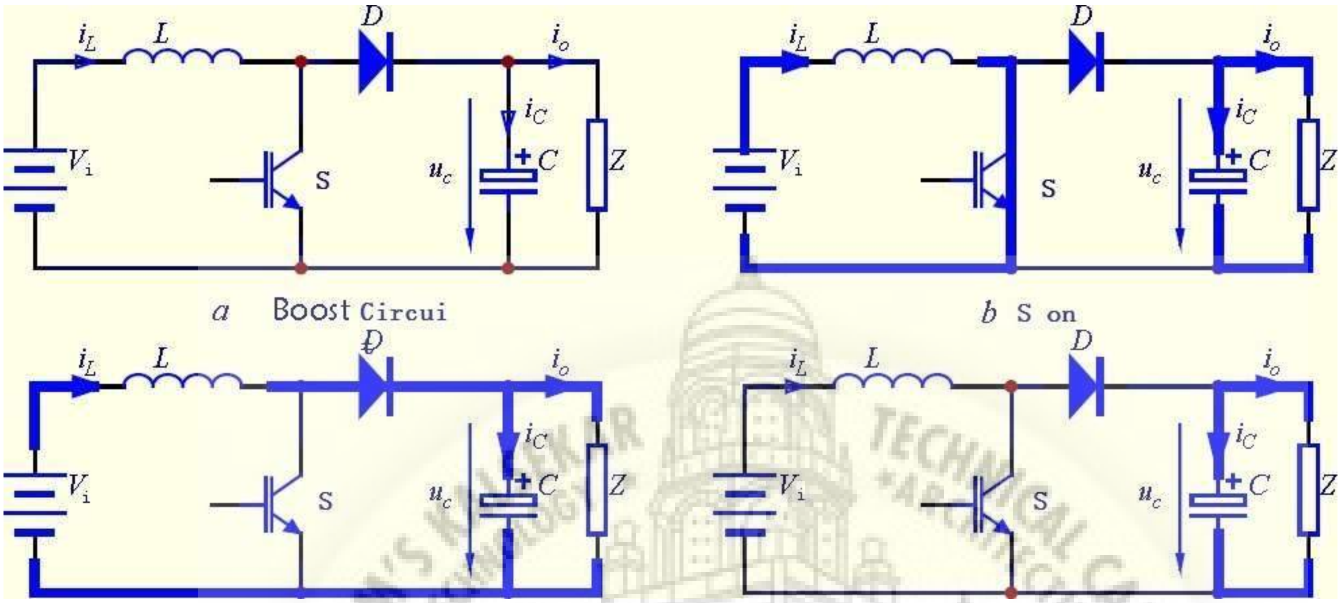


Fig. 2.3.1 Schematic diagram of Buck converter and equivalent circuit under various states of the switch.

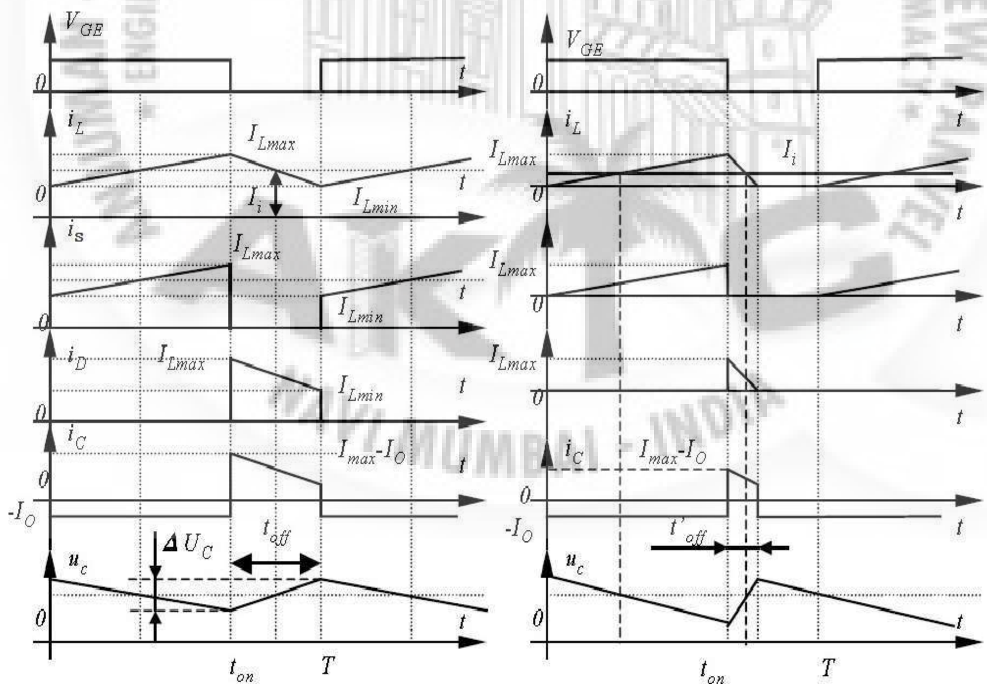


Fig. 2.3.2 Waveform in each point of Buck circuit

If we put the Square Wave signal as an input signal and the switch changes its state in a certain period, the continuity of the current in the inductor iL depends on the switching frequency, the inductor and the capacitor. The operating waveforms of inductor current i_L under continuous conditions are shown in Fig.2.3.2.

Analysis of the circuit working under a steady state is shown as follows:

1) Continuous Current Mode (CCM)

Switch Status 1: S-on（ $0 \leq t \leq ton$）

At moment of t=0, the switch is turned on and the diode D is turned off, the equivalent circuit is shown in Fig. 2.3.1 (b). At this moment, if V0 remain unchanged during this period,

$$V_i - V_o = u_l = L\frac{di_l}{dt} \quad (2.3.3)$$

Apparently $dt=t_{on}$ then

$$\frac{V_i - V_o}{L}dt = di_l \Rightarrow \Delta i_{l(on)} = \frac{V_i - V_o}{L}t_{on} \quad (2.3.4)$$

This is the current change in the process of switch conduction

Switch Status 2: S-off（ ton≤t≤T）

At the moment of t=ton, S turns off, current of the inductor which stores energy can not suddenly change, thus across the inductor L generated a opposite self-induced electromotive force(EMF) voltage to the original polarity. This EMF makes the diode D forward biased. The energy stored in the inductor is transferred to load through the diode D. The equivalent circuit is shown in Fig.2.3.1(c), for this period dt=toff , we can have

$$di_l = -\frac{V_o}{L} t_{off} \Rightarrow \Delta i_{l(off)} = \frac{V_o}{L} t_{off} \quad (2.3.5)$$

L.e. the change of current during turn-off.

Obviously, the circuit achieve balance only when increasing of inductance current during conduction period (inside ton) equals to reduction of the current during closing period (toff). By the formula 2.3.4 and 2.3.5 we can have

Formula 2.3.7 shows that the average output voltage of Buck circuit is proportional to the duty cycle δ, the duty cycle varies from 0 to 1, it means the output voltages changes from 0 to Vi and the maximum output voltage does not exceed Vi .

Because the average current in the capacitor in the switching period must be zero, if not, the value of the voltage at the end of a switching period would be different from the initial value, so we can get

$$i_c = i_1 - I_0 \rightarrow I_c = I_1 - I_0 \rightarrow I_1 = I_0 \quad (2.3.9)$$

ripple of voltage is obtained from the following expression:

$$\Delta U_c = u_c - U_o = \frac{1}{C}\int i_c dt$$

$$\Delta U_c = \frac{1}{2C}\left(I_{C\max} \frac{t_{on} + t_{off}}{2} \right) = \frac{1}{2C}\frac{\Delta I_l}{2}\frac{T}{2} = \frac{\Delta I_l}{8Cf} \quad (2.3.10)$$

From 2.3.9 and 2.3.10 :

$$\Delta U_c = \frac{V_i - V_o}{8LCf^2}\delta = \frac{V_o(1-\delta)}{8LCf^2} \quad (2.3.11)$$

We can understand that reduction of voltage is not only related to input and output voltage ,but also it increases the inductor L and the filter capacitor C can play a significant effect and raise operating frequency of the semiconductor devices can also receive the same effect. As known, ΔUc, Vi, Vo and f can determine the values of C and L according to the Formula 2.3.11.

2) Discontinuous Current Mode (DCM)

Fig. 2.3.14shows the working waveform of DCM. It has three operation modes:

① S turns on, the inductor current iL increases from zero to ILmax;
② S off ,D on, iL drops from ILmax to zero;

③ S and D are both closed, in the meantime iL remain at zero, the load current is supplied from the capacitor.

These three operation modes correspond to three different circuit structure shown in Fig. 2.3.1(b), (c), (d).

When S is on, the inductor current growing from zero , the amount is

$$\Delta i_l = \frac{V_i - V_o}{L} t_{on} \quad (2.3.12)$$

When S is off and the current reduces to zero

$$\Delta i_l = \frac{V_o}{L}\left(t_{on} + t'_{off}\right) \quad (2.3.13)$$

Then from 2.3.12 and 2.3.13 we can get

$$\frac{V_o}{V_i} = \frac{t_{on}}{t_{on} + t'_{off}} = \frac{t_{on}/T}{t_{on}/T + t'_{off}/T} = \frac{\delta}{\delta + \delta'} \quad (2.3.14)$$

In CCM $\delta + \delta' = 1$, in DCM $\delta + \delta' < 1$.

The output current of the converter equals to the average inductor current:

$$I_l = \frac{Q}{T} = \frac{1}{T}\frac{1}{2}\Delta i_l\left(t_{on} + t'_{off}\right) = \frac{\delta^2}{2fL}\left(\frac{V_i}{V_o} - 1\right)V_i \quad (2.3.15)$$

The equation above indicates, on DCM mode, Vo/Vi is not only related to duty cycle δ, but also related to load current.

II Boost (Step-up) converter

A boost converter is also called as step-up chopper, it's a DC / DC converter with a higher output voltage of input. It can be seen from Fig. 2.3.16(a)

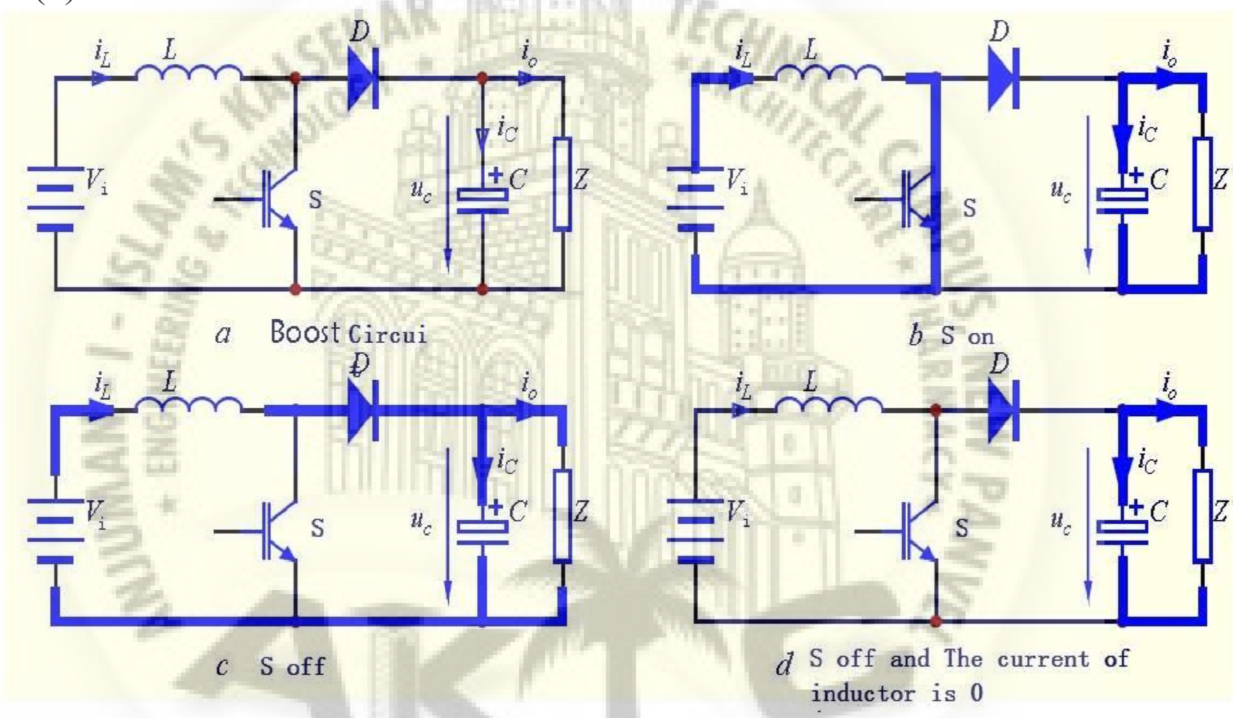


Fig. 2.3.16 Schematic diagram of Boost converter and equivalent circuit under various states of the switch

1) Continuous Current Mode (CCM)

Switch Status 1: S-on（ $0 \leq t \leq ton$）

At the moment of t=0, the switch is turned on and the diode D is turned off, the equivalent circuit is shown in Fig. 2.3.16 (b). At this moment, the current of the inductor is :

$$V_i = L\frac{di_l}{dt} \Rightarrow \frac{di_l}{dt} = \frac{\Delta i_l}{t_{on}} = \frac{V_i}{L} \quad (2.3.17)$$

And

$$\Delta i_{l(on)} = \frac{V_i}{L} t_{on} = \frac{V_i}{L} \delta T \quad (2.3.18)$$

Switch Status 2: S-off (ton≤t≤T)

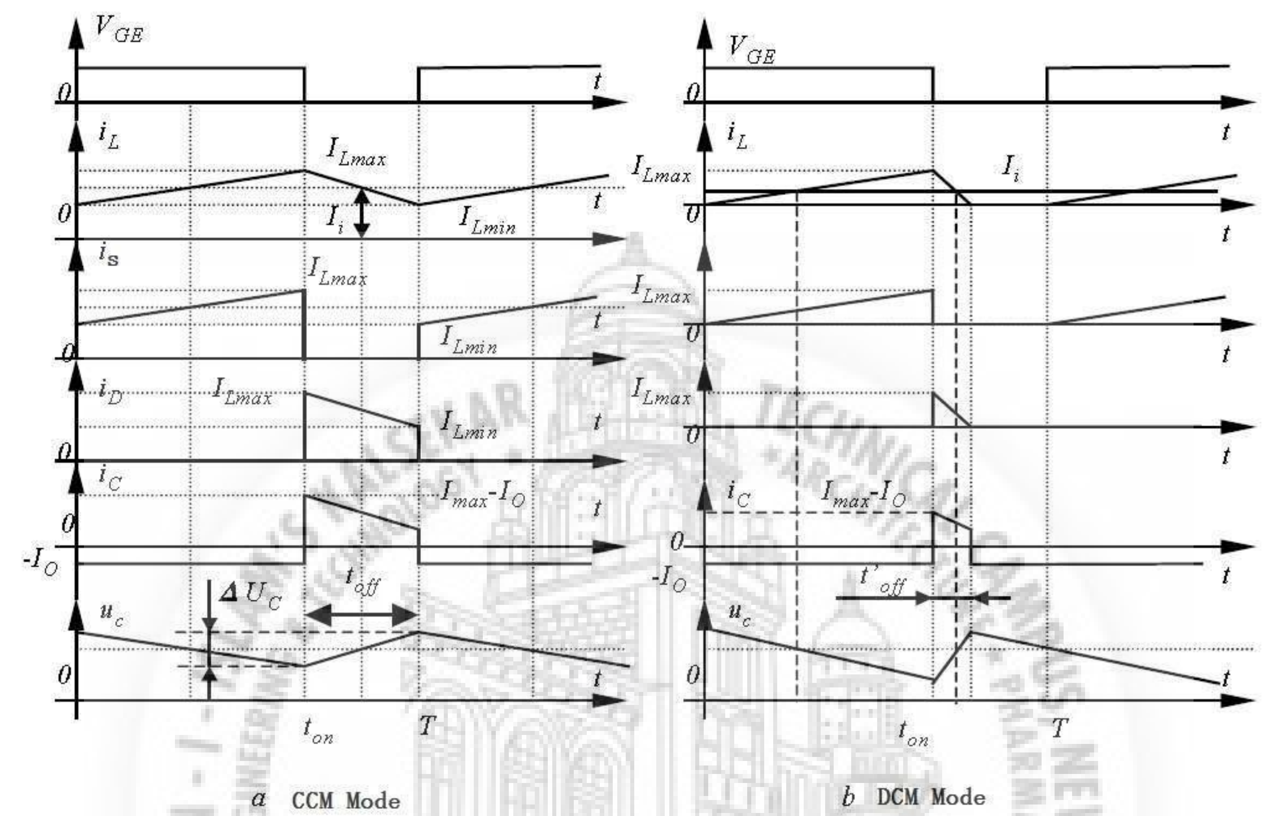


Fig. 2.3.19 Waveform in each point of Boost circuit

After the time of t = ton, S turns off, the equivalent circuit is shown in Fig.2.3.16(c). The diode is forward biased. The energy of Source Power and the energy storage in L are supplied to the load and the filter capacitor C through the diode D. At this moment, voltage imposed on the inductor is Vi-Vo, the current flowing through the inductor i_1:

$$V_i - V_o = L\frac{di_l}{dt} \Rightarrow \frac{di_l}{dt} = \frac{\Delta i_l}{t_{off}} = \frac{V_i - V_o}{L}$$

$$\Delta i_{l(off)} = \frac{V_o - V_i}{L} t_{off} = \frac{V_o - V_i}{L}(1-\delta)T \quad (2.3.20)$$

The increased inductor current in conduction period (inside ton) must equal to (inside toff) decreasement during cut-off period. From 2.3.18 and 2.3.20 we can have:

$$\frac{V_i}{L}\delta T = \frac{V_o - V_i}{L}(1-\delta)T \Rightarrow V_o = \frac{V_i}{1-\delta} \quad (2.3.21)$$

Equation 2.3.21 shows that Boost converter can improve output voltage. When the duty cycle δ varies from zero to 1, output voltage is changed from Vi to arbitrarily large.

2) Discontinuous Current Mode(DCM)

Similar to the Buck converter, the Boost converter has three states on DCM mode:

① S turns on, the inductor current iL increases from zero to ILmax;
② S turns off ,D turns on, iL drops from ILmax to zero;
③ S and D are both closed, in the meantime iL remain at zero, load current is supplied from the capacitor.

The equivalent circuit structures of these three modes during operation are shown in Fig. 2.3.16(b), (c), (d).

When S is on, the growth amount of the inductor current is:

$$\Delta i_{l(on)} = I_{l\max} = \frac{V_i}{L}t_{on} \quad (2.3.22)$$

After S turns off, the inductor current iL decreases linearly from ILmax and at the moment t = ton +t'off drops to zero, that's:

$$\Delta i_{l(off)} = I_{l\max} = \frac{V_o - V_i}{L} t'_{off} \quad (2.3.23)$$

Then Δil(on) must equals to $\Delta i_{1(off)}$, from 2.3.22 and 2.3.23 we can obtained the ratio of Vi and Vo in Formula 2.3.26 , and in the formula δ' = t'off/T

$$\frac{V_o}{V_i} = \frac{t_{on} + t'_{off}}{t'_{off}} = \frac{\delta + \delta'}{\delta'} \quad (2.3.24)$$

The converter works on DCM mode if δ'<1-δ, so we can make $t'_{off}=t_{off}$ to get the average output current($I_o=I_D$) of critical state.

III Ćuk converter

The Ćuk converter is named after Slobodan Ćuk of the California Institute of Technology, who firstly presented the design. It uses a capacitor as its main energy-storage component, which isn't similar to most other types of the converters with an inductor. This converter uses the two inductors, one in the input terminal, an another is in the output terminal, which thereby reduces the current pulse.

The circuit of the Cuk converter is shown in Fig. 2.3.26.

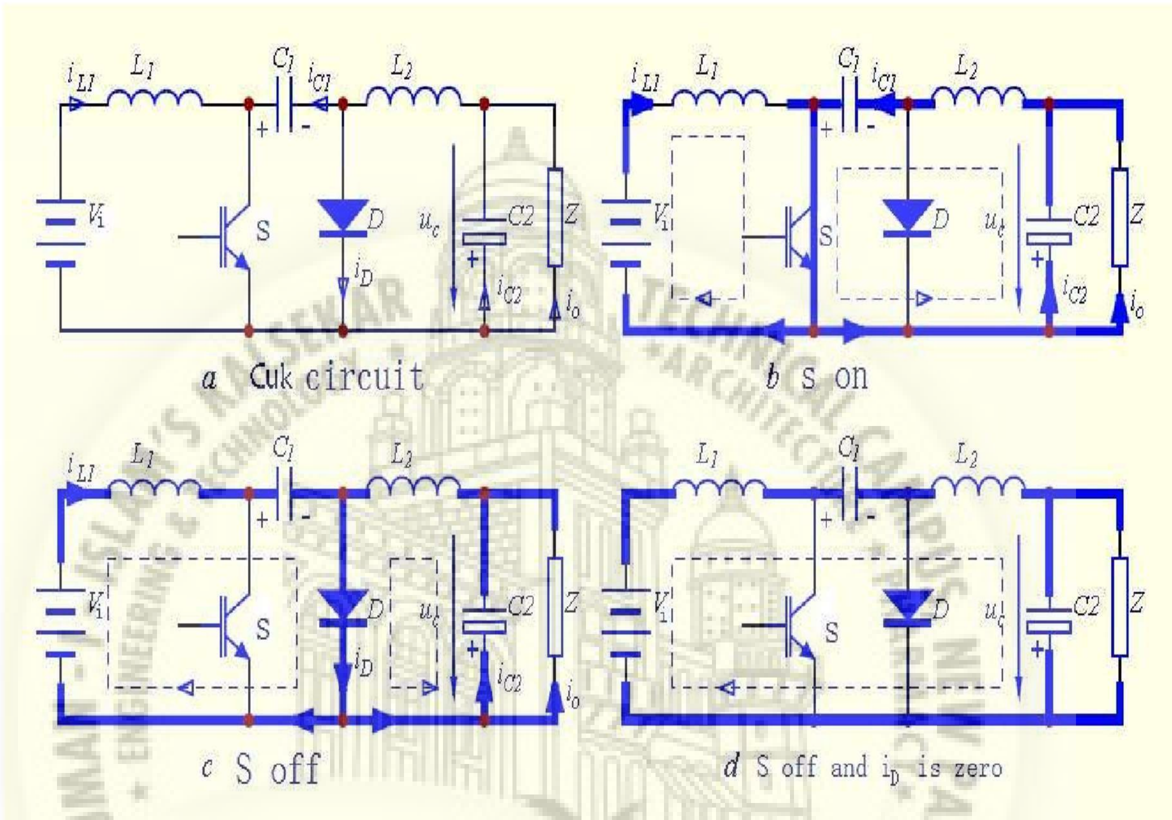


Fig 2.3.26 Circuit schematic of Cuk and equivalent circuit

The Cuk converter can have opposite polarity between input and output, output voltage can be higher or lower than the input voltage, and its input and output currents24 are continuous. In CCM, operating waveforms is shown in Fig. 2.3.27

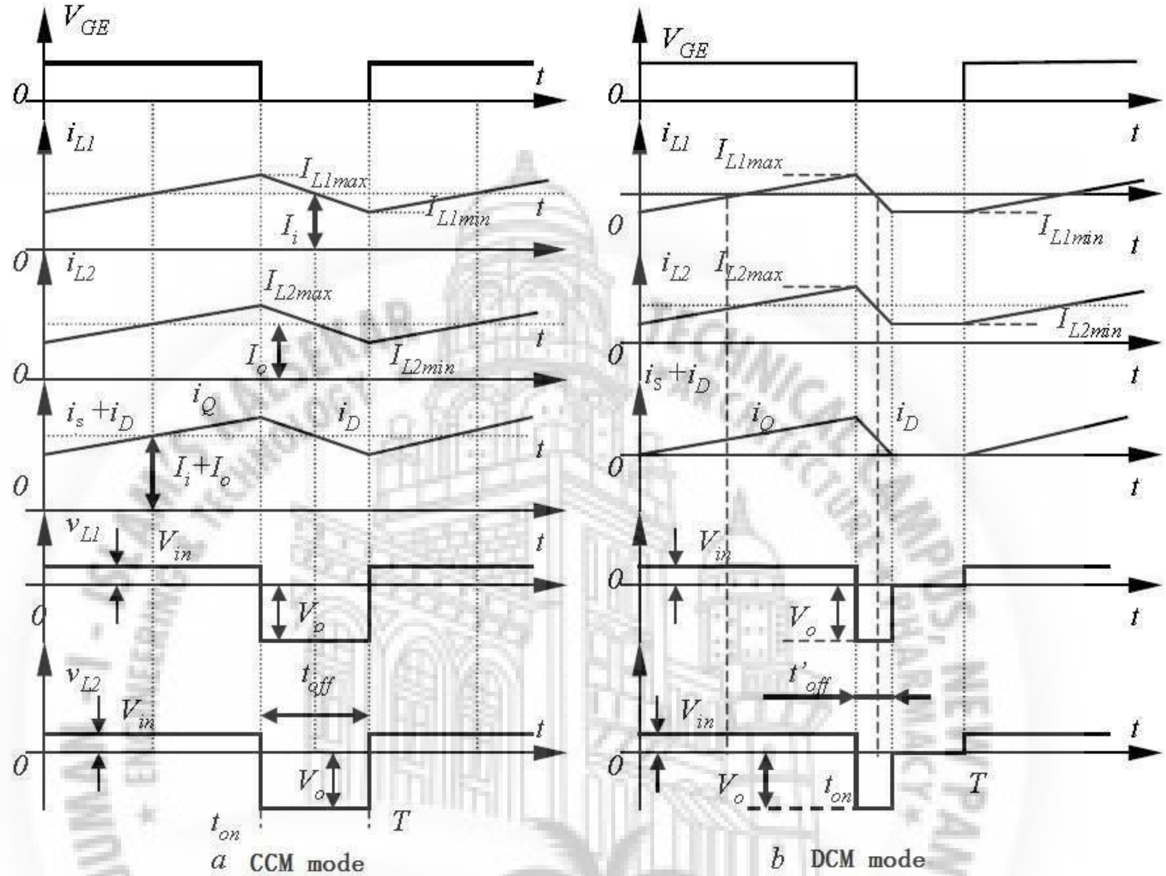


Fig. 2.3.27 Operating waveforms of Cuk converter

State 1: Before S on (t<0)

The voltage at left of conductor C1 is VC1, the voltage equals to earth potential due to the clamping diode D at right.

State 2: S on（ 0≤t≤ton）

During this period, S conduction, the equivalent circuit is shown in Fig. 2.3.26b. The inductor L1 charges energy, the capacitor voltage on the capacitor C1 can not be change suddenly, it makes D reverse bias and the voltage on the left of L2 is -VC1 and then C1 transmits energy through the load Z and L2 , the load obtains a reverse polarity voltage, L2 and C2 begin to store energy. In this circuit configuration, S and diodes D are synchronized to work, S conduction, D cutoff; S off, D conduction.

During the ton, the current of L1 rises linearly with the rate Vi/ L1, the current increment is:

$$\Delta i_{l1(+)} = \frac{V_i}{L_1} t_{on} = \frac{V_i}{L_1} \delta T \quad (2.3.28)$$

And current increment of L_2 is:

$$\Delta i_{l2(+)} = \frac{V_{c1} - V_o}{L_2} t_{on} = \frac{V_{c1} - V_o}{L_2} \delta T \quad (2.3.29)$$

State 3: S off（ ton≤t≤T ）

During the period toff, S cutoff, the equivalent circuit is shown in Fig. 2.3.26c. D is turned on, capacitor C1 is charged, L1 charge energy to C1 through D. At the same time L2 release energy to the load, in this circuit configuration, no matter in the ton period o in the toff period, the input terminal will transmit energy to the load. As long as the inductor L1, L2 and the capacitor C1 is large enough, input and output current is essentially smooth. C1 is charged and store energy during the toff then discharge and transmit energy to load during ton , C1 plays a role during energy transfer.

In this period of toff, L1 releases energy, voltage drops of Vi-VC1, the current in L1 decreases linearly at a rate (Vi-VC1)/L1, the current reduction is:

$$\Delta i_{l1(-)} = \frac{V_i - V_{C1}}{L_1} t_{off} = \frac{V_i - V_{C1}}{L_1}(1-\delta)T \qquad (2.3.30)$$

Voltage of L_2 is $-V_o$,The current reduction of L_2 is:

$$\Delta i_{l2(-)} = \frac{-V_o}{L_2} t_{off} = \frac{-V_o}{L_2}(1-\delta)T \qquad (2.3.31)$$

In the steady state, change of inductor current should be equal for L_1, considering 2.3.28 and 2.3.30 we have:

$$\frac{V_i}{L_1} t_{on} = \frac{V_i - V_{C1}}{L_1} t_{off} \Rightarrow V_{C1} = V_i\left(1 - \frac{t_{on}}{t_{off}}\right) = \frac{V_i(1-2\delta)}{1-\delta} \qquad (2.3.32)$$

For L_2, we need take into account 2.3.29 and 2.3.31 :

$$\frac{V_{c1}-V_o}{L_2}t_{on}=\frac{-V_o}{L_2}t_{off}\Rightarrow V_{c1}=-\frac{V_o(1-2\delta)}{\delta} \quad (2.3.33)$$

If C_1 is large enough, voltage during t_{on} and t_{off} period can be considered approximately constant (only a small changes), so there we have:

$$\frac{V_i(1-2\delta)}{1-\delta}=-\frac{V_o(1-2\delta)}{\delta}\Rightarrow V_o=-\frac{\delta V_i}{1-\delta} \quad (2.3.34)$$

From 2.3.34 We can understand that the output voltage can be less than, or equal to, or greater than the input voltage, it depends on the value of duty cycle.

In general, output voltage of the photovoltaic cell has great fluctuations, and the buck boost converter can only reduce voltage or rise voltage. The solar cells are difficult to completely work at maximum power point for this reason, which results working efficiency of the system decreased. Meanwhile, the input current ripple of the Buck converter is large. If the input terminal works without an energy storage capacitor, it will make the system work in intermittent mode, which results the photovoltaic cell output the current unsteady and can not be in top working condition; Rather the output current ripple of Boost converter is large, and using this instable current to charge the battery is not conducive to the battery's life. The Cuk converter has both boost and buck function, using it in charge controller of the photovoltaic system can better achieve maximum power point tracking and help to improve efficiency of the system. According to this, we often use the Cuk converter as a main circuit of charge controller .

2.3.2 Maximum Power Point tracking (MPPT)

Output power of the solar panels is not only linked with light intensity, but also with load current. From V-I curve of the solar cell we can find the existence of a maximum 27 power point. In order to obtain most energy in sunlight,it is necessary to take measures to make load characteristics of the solar cells can automatically trace changes of the climate conditions. The solar panels Maximum Power Point tracking (MPPT) technology is proposed for this problem. There are currently several common control strategies:

A. Hill Climbing and perturb and observe (P&O) .

B. Fuzzy Logic Control .

C. Fractional Short-Circuit Current .

2.3.3 Charge and discharge management

Another function of the controller is to manage charging and discharging of the battery.

Rated voltage	Anti-overcharge voltage	Anti-over discharge voltage
6V	7.2V ±0.1v	5.5V±0.1V

12V	14.3V ±0.1V	11.0V±0.1V
24V	28.6V ±0.1V	22.0±0.1V

Table 2.3.35 Overcharge, Over-discharge protection voltage

The large-capacity lead-acid battery can be charged with large current in order to fully charge in a limited time during day time. When voltage of the battery's cell reaches limit voltage, it could easily lead to breakage of battery if it still uses a large current to charge. Therefore, when the battery reaches the overcharge voltage, it Can be automatically converted into a trickle charge(small current). The general parameters of protection voltage has shown in Table 2.3.35, in generally the over-discharge protection voltage is 90% of the nominal voltage and the overcharge protection voltage is usually 120% of the nominal voltage. The precision of anti-overcharge 28 control voltage is ± 0.1v.

The working life under different depth of discharge is not the same, in particular deep discharging of the battery can cause permanent damage. In order to protect the battery life, we must avoid deep discharge. When the battery voltage falls below over discharge point, it should promptly cut off load and stop lighting. Once the protection circuit act, we must ensure that the battery does not automatically discharge anymore before no recharging.The general parameters of battery overcharge, overdischarge protection voltage are shown in Table 2.3.35. When the battery voltage reaches the set value, then change state of the circuit.

.

2.3.4 Automatic switch of lamp

The LED lights automatically turn on in the evening and automatically turns off power supply at dawn or certain time , this is the time control function of the controller.
It should be noted that: In the evening and dawn, the ambient light changes slowly, the brightness still varies during this process . In general, we can add a delay circuit(A few minutes) in the light control circuit. Thus, when the lights turn on or turn off , there will be no flicker phenomenon.

2.4 LED light

Most solar LED street light systems choose the high-power white LED as the lighting source now. Compared to other lighting source, it has a remarkable energy saving, low maintenance cost and several advantages, Thus it's very suitable for the public lighting.

2.4.1 Principle of LED light

All LEDs emit light spectra with narrow-band light (almost monochromatic). Heterochromatic light which is required to illuminate environments is obtained by radiation mixing. There are two primary ways to produce white light-emitting diodes. One is to use two or more different color lights and then mix them together to form the white light. For example, the RGB technic which use the three primary colors (red, green, and blue). Hence the method is called as the multi-color white LEDs. This

method is particularly interesting in many uses because of the flexibility of mixing different colors. In principle, this mechanism also has higher quantum efficiency inproducing white light.
Also there are many other types of the multi-color white LEDs:
Dichromatic, Trichromatic and Tetrachromatic. Another technic is Phosphor-based LEDs, that means a phosphor material is used to convert monochromatic light from a blue or UV LED to broad-spectrum white light, much in the same way as fluorescent light bulb works.

2.4.2 Main parameters

The V-I characteristic curve of the LED is much like PN junction, We can see from the Fig. 2.4.1, a small voltage change may result in a large change in current. It is 30 therefore important that LEDs should be connected to constant-current sources. The instable current will shorten the life of the LED and affect the light failure.

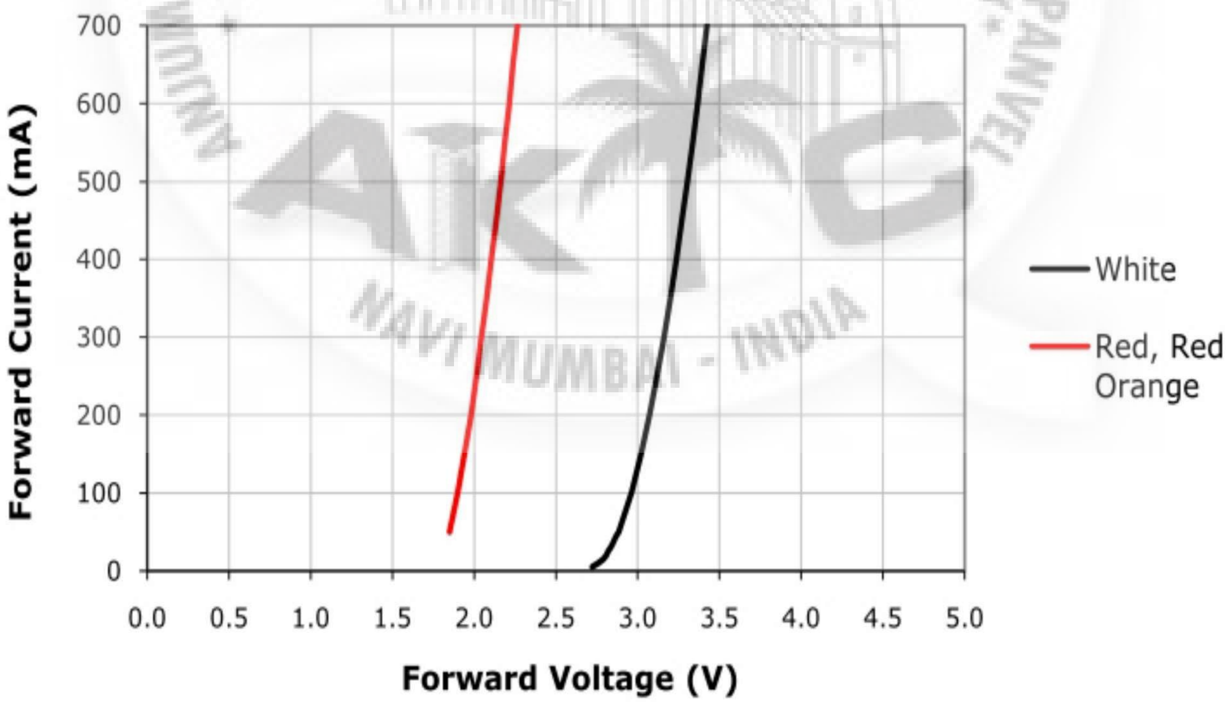


Fig. 2.4.1 Current-voltage graph of LED

The luminous flux is a photometric quantity that measures the perceived power of light. It is adjusted to reflect the various sensitivity of the human eye to different wavelengths of light. The luminous flux is an important indicator of lighting LED and is directly related to the current. As the current increases, the luminous flux of LED's increases too, the relationship between them is shown in Fig. 2.4.2.

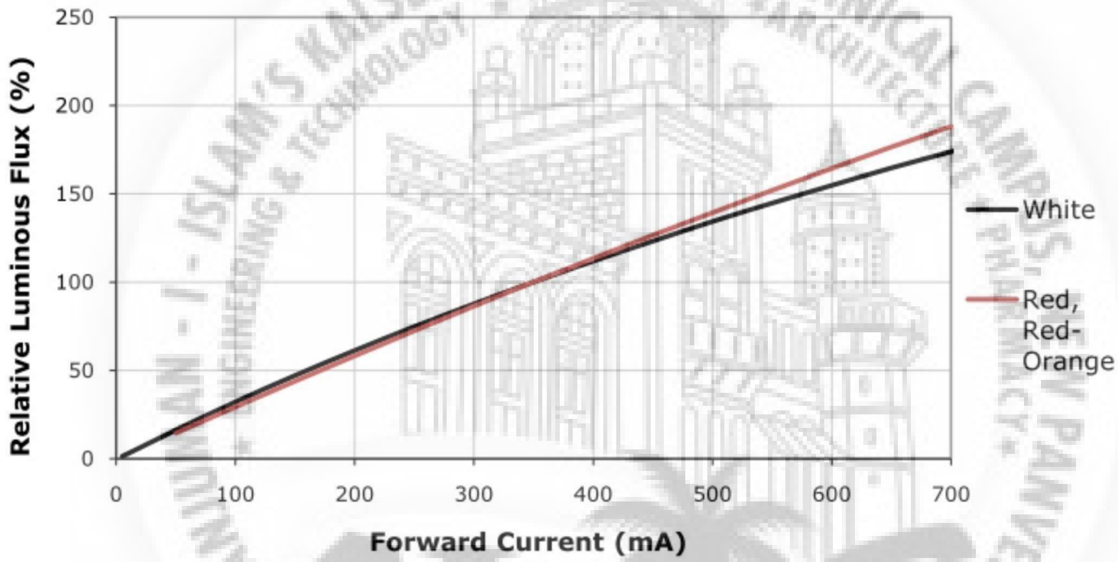


Fig. 2.4.2 Chart of drive current - flux emitted

For this reason it is generally contraindicated to increase the driving current in order to increase the luminous flux, because the loss of efficiency additionally decreases life of the LED.

2.4.3 Calculate number of LED

According to the actually lighting requirement on luminous flux and the flux of single LED, we can get the number of LED. Calculation is shown as follows:

$$n_{LED} = \frac{\sum \Phi_v}{\Phi_{vLED}} \frac{1}{\eta_1 \eta_2} \quad (2.4.3)$$

$\Sigma \Phi_v$: Objective luminous flux, can be calculated from the illumination requirements.
$\Phi\ v_{LED}$: Minimum luminous flux of single LED. (lm)
η1 : Optical Efficiency η2: Thermal efficiency

2.4.4 Advantages and disadvantages of white LED

The high-power LED is called as "green light". As the light source for illumination, it has the following advantages:

* Long lifetime (35,000 to 50,000 hours of useful life);

* Low maintenance costs and replacement costs;

* High efficiency;

* Clean light (no IR and UV components);

* Safety (working in low voltage 3 ~24V);

* Small (smaller than 2 mm) and quickly.

Chapter 3

Current Scenario – Consumption Of Solar Energy.

3.1 National solar potential.

With about 300 clear and sunny days in a year, the calculated solar energy incidence on India's land area is about 5000 trillion kilowatthours (kWh) per year (or 5 EWh/yr). The solar energy available in a single year exceeds the possible energy output of all of the fossil fuel energy reserves in India. The daily average solar-power-plant generation capacity in India is 0.30 kWh per m^2 of used land area, equivalent to 1400–1800 peak (rated) capacity operating hours in a year with available, commercially-proven technology.

The Climate of Mumbai is a tropical, wet and dry climate. Mumbai's climate can be best described as moderately hot with high level of humidity. ... Summer (March to May) Avg temperature 30 to 27°C; Peak Summer Months (Mid March to 1 June week), temperature shoots up to 30–40°C with humidity being approx 70–80%

Solar power in India is a fast developing industry. The country's solar installed capacity was 36.9 GW as of 30 November 2020.

The Indian government had an initial target of 20 GW capacity for 2022, which was achieved four years ahead of schedule. In 2015 the target was raised to 100 GW of solar capacity (including 40 GW from rooftop solar) by 2022, targeting an investment of US$100 billion. India has established nearly 42 solar parks to make land available to the promoters of solar plants

Solar photovoltaic growth forecasts

In August 2016, the forecast for solar photovoltaic installations was about 4.8 GW for the calendar year. About 2.8 GW was installed in the first eight months of 2016, more than all 2015 solar installations. India's solar projects stood at about 21 GW, with about 14 GW under construction and about 7 GW to be auctioned. The country's solar capacity reached 19.7 GW by the end of 2017, making it the third-largest global solar market.

In mid-2018 the Indian power minister RK Singh flagged a tender for a 100GW solar plant at an event in Delhi, while discussing a 10GW tender due to be issued in July that year (at the time, a world record). He also increased the government target for installed renewable energy by 2022 to 227GW.

Solar thermal power

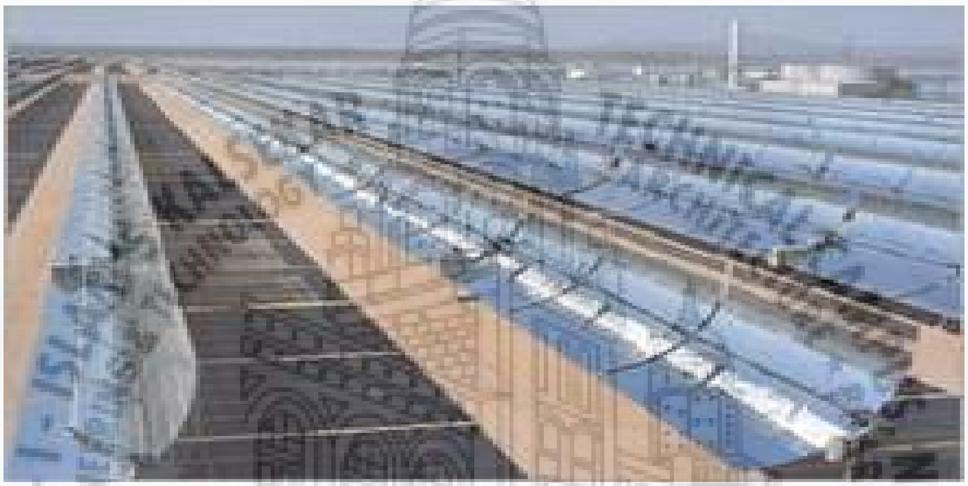
The installed capacity of commercial solar thermal power plants (nonstorage type) in India is 227.5 MW with 50 MW in Andhra Pradesh and 177.5 MW in Rajasthan. The existing solar thermal power plants (nonstorage type) in India, which are generating costly intermittent power on a daily basis, can be converted into storage type solar thermal plants to generate 3 to 4 times more base load power at cheaper cost and not depend on government subsidies. In March 2020, SECI called for 5000 MW tenders which can be combination of solar PV with battery storage, solar thermal with thermal energy storage (including biomass firing as supplementary fuel) and coal based power (minimum 51% from renewable sources) to supply round the clock power at minimum 80% yearly availability.

Hybrid solar plants

Solar power, generated mainly during the daytime in the non-monsoon period, complements wind which generate power during the monsoon months in India. Solar panels can be located in the space between the towers of wind-power plants. It also complements hydroelectricity, generated primarily during India's monsoon months. Solar-power plants can be installed near existing hydropower and pumped-storage hydroelectricity, utilizing the existing power transmission infrastructure and storing the surplus secondary power generated by the solar PV plants. Floating solar plants on the reservoirs of pumped-storage hydroelectric plants are complementary to each other. Solar PV plants clubbed with pumped-storage hydroelectric plants are also under construction to supply peaking power.

During the daytime, the additional auxiliary power consumption of a solar thermal storage power plant is nearly 10% of its rated capacity for the process of extracting solar energy in the form of thermal energy. This auxiliary power requirement can be made available from cheaper solar PV plant by envisaging hybrid solar plant with a mix of solar thermal and solar PV plants at a site. Also to optimise the cost of power, generation can be from the cheaper solar PV plant (33% generation) during the daylight whereas the rest of the time in a day is from the solar thermal storage plant (67% generation from Solar power tower and parabolic trough types) for meeting 24 hours baseload power. When solar thermal storage plant is forced to idle due to lack of sunlight locally during cloudy days in monsoon season, it is also possible to consume (similar to a lesser efficient, huge capacity and low cost battery storage system) the cheap excess grid power when the grid frequency is above 50 hz for heating the hot molten salt to higher temperature for converting stored thermal energy in to electricity during the peak demand hours when the electricity sale price is profitable.

Solar Heating.



Array of parabolic troughs.

Generating hot water or air or steam using concentrated solar reflectors, is increasing rapidly. Presently concentrated solar thermal installation base for heating applications is about 20 MW_{th} in India and expected to grow rapidly. Cogeneration of steam and power round the clock is also feasible with solar thermal CHP plants with thermal storage capacity.

Bengaluru has the largest deployment of roof-top solar water heaters in India, generating an energy equivalent of 200 MW. It is India's first city to provide a rebate of ₹50 (70¢ US) on monthly electricity bills for residents using roof-top thermal systems, which are now mandatory in all new structures. Pune has also made solar water heaters mandatory in new buildings. Photovoltaic thermal (PVT) panels produce simultaneously the required warm water/air along with electricity under sunlight.

Rural Electrification.

The lack of an electricity infrastructure is a hurdle to rural India's development. India's power grid is under-developed, with large groups of people still living off the grid.

In 2004, about 80,000 of the nation's villages still did not have electricity, 18,000 out of them could not be electrified by extending the conventional grid due to inconvenience. A target of electrifying 5,000 such villages was set for the 2002–2007 Five-Year Plan. By 2004 more than 2,700 villages and hamlets were electrified, primarily with solar photovoltaic systems.

The development of inexpensive solar technology is considered a potential alternative, providing an electricity infrastructure consisting of a network of local-grid clusters with distributed electricity generation.

It could bypass (or relieve) expensive, long-distance, centralized powerdelivery systems, bringing inexpensive electricity to large groups of people.

In Rajasthan during Financial Year 2016–17, 91 villages have been electrified with a solar standalone system and over 6,200 households have received a 100W solar home-lighting system.

India has sold or distributed about 1.2 million solar home-lighting systems and 3.2 million solar lanterns, and has been ranked the top Asian market for solar off-grid products.

Lamps and lighting

By 2012, a total of 4,600,000 solar lanterns and 861,654 solar-powered home lights were installed. Typically replacing kerosene lamps, they can be purchased for the cost of a few months' worth of kerosene with a small loan. The Ministry of New and Renewable Energy is offering a 30- to 40percent subsidy of the cost of lanterns, home lights and small systems (up to 210 W_p). Twenty million solar lamps are expected by 2022.

Agricultural support

Solar photovoltaic water-pumping systems are used for irrigation and drinking water. Most pumps are fitted with a 200–3,000 W (0.27– 4.02 hp) motor powered with a 1,800 W_p PV array which can deliver about 140,000 litres (37,000 US gal) of water per day from a total hydraulic head of 10 m (33 ft). By 31 October 2019 a total of 181,521 solar photovoltaic water pumping systems were installed and total solar photovoltaic water pumping systems would reach 3.5 million by the year 2022 under PM KUSUM scheme. During hot sunny daytime when the water needs are more for watering the fields, solar pumps performance can be improved by maintaining pumped water flowing/sliding over the solar panels to keep them cooler and clean. Agro photovoltaics is the electricity generation without losing agriculture production by using the same land. Solar driers are used to dry harvests for storage. Low cost solar powered bicycles are also available to ply between fields and village for agricultural activity, etc.

Rainwater harvesting

In addition to solar energy, rainwater is a major renewable resource of any area. In India, large areas are being covered by solar PV panels every year. Solar panels can also be used for harvesting most of the rainwater falling on them and drinking or breweries water quality, free from bacteria and suspended matter, can be generated by simple filtration and disinfection processes, as rainwater is very low in salinity. Good quality water resources, closer to populated areas, are becoming a scarcity and increasingly costly for consumers. Exploitation of rainwater for valueadded products like bottled drinking water makes solar PV power plants profitable even in high rainfall and cloudy areas by the increased income from drinking water generation

Refrigeration and air conditioning.

4 MW horizontal single-axis tracker in Vellakoil, Tamil Nadu

Thin-film solar cell panels offer better performance than crystalline silica solar panels in tropical hot and dusty places like India; there is less deterioration in conversion efficiency with increased ambient,

CONCLUSION

LED lights are the future of lighting, because of their lower energy consumption and long life. Providing street lighting is one of the most important and expensive responsibilities of a city.

This project is a cost effective, practical, eco-friendly and safest way to save energy. It takes the problem of disposal of incandescent lamp and energy saving efficiently. LEDs emit cool light, do not have any toxic material and can be used for fast switching.

These mentioned reasons makes this project more advantageous keeping in view the long term benefits.

REFERENCE

A. **WIKIPEDIA**.

1. Electrical Characteristics of Photovoltaic Cells
2. Application Research in the Solar Street Lamp Management Based on the LED Light-emitting Diodes.
3. Light-emitting diode.
4. Maximum power point tracking.
5. Rechargeable battery.
6. Lead–acid battery.

B. **IEEE JOURNAL.**

1. International Journal of Scientific & Engineering Research, Volume 7, Issue 7, July-2016 34 ISSN 2229-5518 IJSER © 2016 http://www.ijser.org Solar Powered LED Street Lighting with Auto Intensity Control Ch Kavitha, Swathi, Satyaprakash, Vinitha

2. Solar Panel Section.

3. Measurement of Solar Photovoltaic Power Circuit.

C. Photovoltaic Geographical Information System. Available at: http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php#

D. Solar Angles and Tracking Systems. Available at:

http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_pveff/cub_pveff_lesson01.xml