Design of LED Based Solar Power Lantern

A Project report submitted in partial fulfillment

of the requirements for the degree of B. Tech in Electrical Engineering

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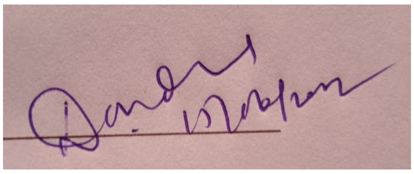
CERTIFICATE

<u>To whom it may concern</u>

This is to certify that the project work entitled "**<u>Design of LED based Solar Power Lantern</u>**" is the bona fide work carried out by **<u>Reetam Bag, Prithviraj Roy, Swarnava Deb, Preeti Paswan</u>**, a student of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 20 21-22, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any otherdegree, diploma and fellowship.



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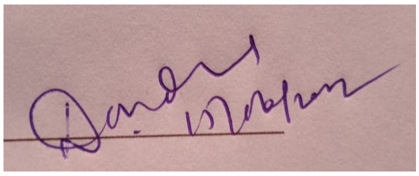

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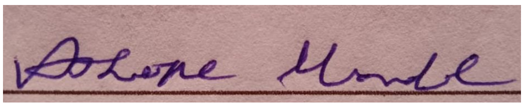

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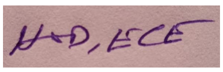
Designation: 

Abstract

Over half a billion children is suffering from lack of adequate lighting and they rely on dim, smoky, and dangerous kerosene-based lighting for their evening studies. This paper is on how we can provide our rural students a brighter, clean, safe, and zero-marginal-cost light of solar lamps enhances children's learning outcomes. The solar lamp can provide continuous light of 150 lux for studying properly around 5 to 6 hours; this may be due to flickering from lack of full charge that lowered their productivity. These solar lamps likely have insignificant effect on educational attainment. The use of the solar lamp will decrease the amount of local air pollution and saves energy. It can provide access to solar lamps at an affordable price to a wide range of people living in remote villages that are deprived of clean energy access. It also came out as an alternative business model with the potential to strengthen the overall rural economy by generating technology-based livelihood opportunities.

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Lists of Units

1. Lux
2. Lumen
3. Watt
4. Celsius
5. m AH
6. Ohm
7. Amp
8. Watt/ hour
9. MW

List of Abbreviations

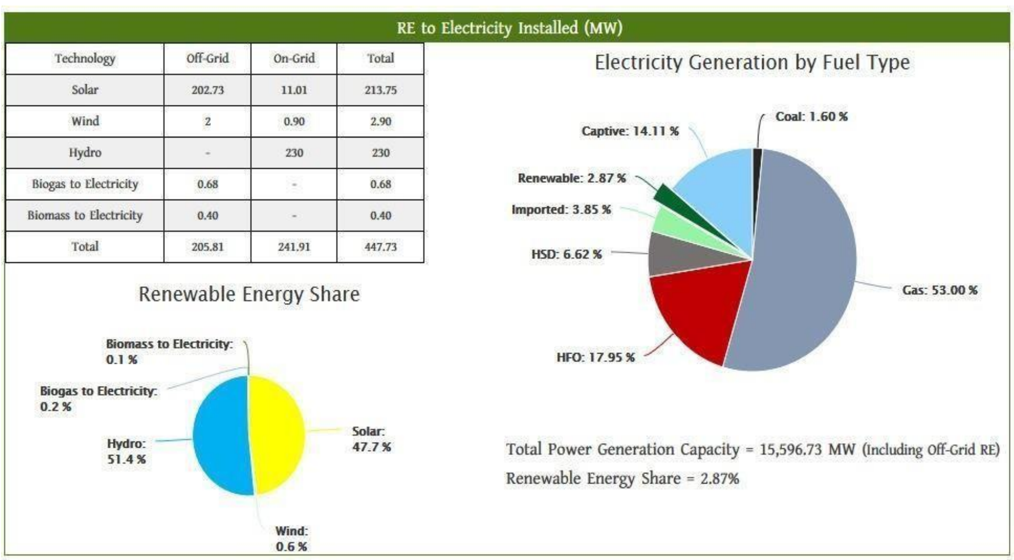
1. **PV CELL- Photovoltaic Cell**
2. **SOP - Small outline packages**
3. **LED – Light Emitting Diode**
4. **PV – Photovoltaic**
5. **PTC – Positive Temperature coefficient**
6. **SSL -Solid State Lighting**
7. **GDP – Gross Domestic Product**
8. **GER – Gross Enrollment Rate**
9. **NER – Net Enrollment Rate**
10. **p-Si – Polycrystalline**
11. **PTC – Positive Temperature Coefficient**
12. **Lipo Battery – Lithium Polymer battery**
13. **SSL – Solid State Lighting**
14. **FC- Foot-candles**
15. **AC - Alternate Current**
16. **DC – Direct Current**
17. **PH – Peak Sunshine hour**

Chapter 1

Introduction

Background Story

India always has progressive development with the growing economy. The demand for electrical energy has increased significantly with the passage of time to meet the challenge of the twenty first century for continuing developing process smoothly. India mainly dependent on fossil based electricity .Since fossil fuels are non-renewable and require finite resources which are declining because of environmentally damaging retrieval technique. Due to such concern, developing countries like India are facing setbacks in sustainable development. As the national grid does not have the capacity to extend to those regions a significant number of households are generating power from solar energy.


RE to Electricity Installed (MW)

Technology	Off-Grid	On-Grid	Total
Solar	202.73	11.01	213.75
Wind	2	0.90	2.90
Hydro	-	230	230
Biogas to Electricity	0.68	-	0.68
Biomass to Electricity	0.40	-	0.40
Total	205.81	241.91	447.73

Fig1.1: RE to Electricity installed

Motivation

Education is one of the fundamental right for the students but India is still lagging behind to meet the challenge of total electricity required a day besides there are so many rural areas and regions where electricity is not reached and available yet. We were motivated to build a solar study lamp which will meet the minimum demand of lightening to study for at least 4 to 5 hours without any interruption. With a very low cost price and with long durability it will help the school going children in their daily studies.

Solar energy is totally clean and renewable and doesn't emit carbon dioxide during its operation. Solar energy is a renewable energy resource that does not generate pollution and has become an increasingly valuable way to diversify the nation's energy options. Spurred by technological advances, falling costs, and rising energy prices, solar energy projects are being developed across the country and being so popular among the rural people. .According to Heinrich Hertz the photovoltaic effect is the phenomena in which electrons at the surface of any matter are emitted by absorbing energy from electromagnetic radiation such as visible light. A material used in photovoltaic effect (PV) known as PV cell, which are generally made by silicon semiconductor device. In PV cell, when sunlight strikes on the surface of PV cell it absorbed solar energy and if absorbed energy is greater than the band gap energy of the semiconductor, the electron from valence band jumps to the conduction band, Which is responsible for solar current.

The major material of photovoltaic panel which is the most commonly used today is silicon, it is a semiconductor device with a positive temperature coefficient i.e. increase in temperature results in increase in resistance and power loss which decreases the efficiency of photovoltaic panel. So for proper operation solar panel should be operating within the reasonable temperature limit. The efficiency of PV system can be increases by using a suitable Maximum power point tracker (MPPT) device that provides a maximum current and voltage to the inverter circuit which enhance the efficiency of PV system. Based on this solar PV system we were motivated to build a cost efficient solar based led light lamp which provides minimum 150 lux of light.

Lighting has important effect upon health and productivity which influence the performance of the student. Good lighting plays an important role in their daily studies to achieve success as it encourages them to give their best performance.

Poor lighting discourages them and it slow down their performance. Besides it’s injurious to health as well. LED or light emitting diode is nowadays very popular and commonly used for lightening system. The use of LED technology in general lighting system is a good option because of its continuous improvements and advantages, including long lifetime, low power cost, the physiological impact to the user, low light pollution and low carbon footprints. According to the study, a LED circuit will approach 80% efficiency, which means 80% of the electrical energy is converted to light energy and the remaining 20% is lost as heat energy. Comparing with incandescent bulbs which operate at 20% efficiency (80% of the electrical energy is lost as heat). LEDs can emit a larger amount of light intensity than any other lamps. Gradually, other lamps experience a gradual reduction in their light output. The more it is used the more it fails to maintain its light output. LEDs do not fall to under this category of lamps thus; it will still give a good measure of light intensity.

So with combination of solar energy and LED; our goal is to make a solar study lamp and testing the performance and to make improvement of life cycle of the lamp in Indian perspective. A solar study lamp is a lightening device consists of a PV module, battery, LED light, and electronics. The solar study lamp is especially suitable for study purpose.

Objective

The aim of this thesis is to investigate fundamental science and technological aspects of generating a cost efficient solar study lamp which will focus on:

1. Reliability
2. Efficiency
3. Costing
4. Testing performance

Thesis Organization

Chapter 1

This introductory chapter provides background information about the overall scenario of India and its electricity capacity and determining the problem. It also includes background to the present research work, describes the objectives and outline of the thesis.

Chapter 2

This chapter explains the necessary components and methods of developing the multipurpose solar study lamp. Also explains the architecture of the solar study lamp.

Chapter 3

In this chapter, different performances testing results and data have been discussed. Besides we calculated overall cost of the product of a single unit.

Chapter 4

This chapter summarizes the whole thesis project and talks about the scope of working. Despite that it also describes some ideas about future progression.

Chapter 2

Architecture of Solar Study Lamp

General Overview of the System:

The solar study lamp is not a single piece of hardware but several electronic devices connected to each other. The very design of separate individual components connected together allows us to add more parts according to our need. When we talk about connecting different blocks of electronic components to each other it is not simple connection at all. The main component blocks are-

- Solar Panel
- TP4056 Module
- Battery
- High Power LED
- Battery Level Indicator

Understanding Tasks and Our Approach:

Here we are trying to make a lamp which is perfect for study at night which will be charger by a solar panel which will charge lithium Ferro phosphate battery is connected with the panel through a module named TP 4056 module which ideally suited for portable applications. The TP4056 can work within USB and wall adapter. Here no blocking diode is required due to the internal PMOSFET architecture and have to prevent negative Charge Current Circuit. By charging the battery we can use the LED light as a study lamp at night. An indicator is included there to identify the battery percentage.

Solar Panel

Background

Photovoltaic (PV) system is a highly competitive technology to convert the incident solar power into electrical energy. Pursuing high efficiency is always the important task for PV technology. However it is still a long way from being competitive with fossil fuel based energy conversion technologies. A major issue is there the limited efficiency of solar energy conversation. Where electricity is still unreached there solar panel energy is mostly important and can play an important role.

Photovoltaic Cell

Photovoltaic cell is a semiconductor device that converts photons into electrical energy by photovoltaic effect. The term "photo" means light and "voltaic" means electricity. When sunlight strikes on a PV cell, the photons of the absorbed sunlight dislodge the electrons from the atoms of the cell. The free electrons then move through the cell, creating and filling in holes in the cell. It is this movement of electrons and holes that generates electricity. The physical process in which a PV cell converts sunlight into electricity is known as the photovoltaic effect. We used in our project Polycrystalline solar panels because it is

- Simpler and cost less.
- The amount of waste silicon is less compared to others
- Polycrystalline solar panels tend to have slightly lower heat tolerance
- This technically means that they perform slightly worse

However, this effect is minor, and most homeowners do not need to take it into account.
There is also some disadvantage like the efficiency of polycrystalline-based solar panels is typically 13-16%. Which will increase the charging time of the battery but for simple electronics device polycrystalline is best.

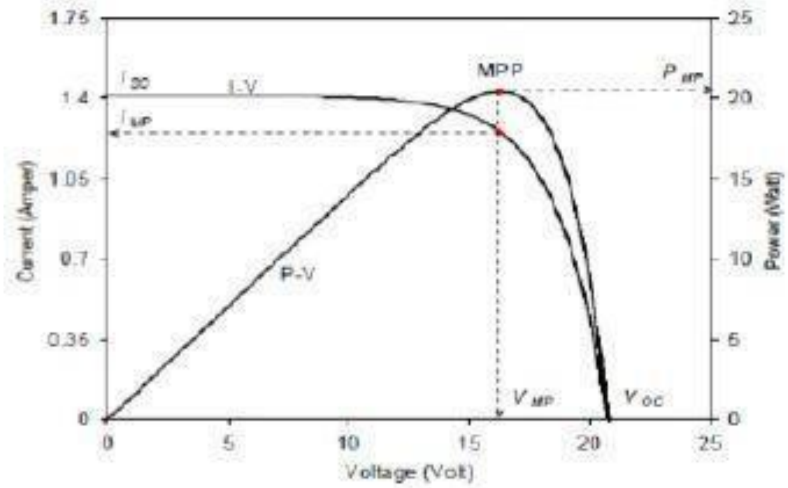


Figure 4.1: Typical I-V and P-V curves for a PV module

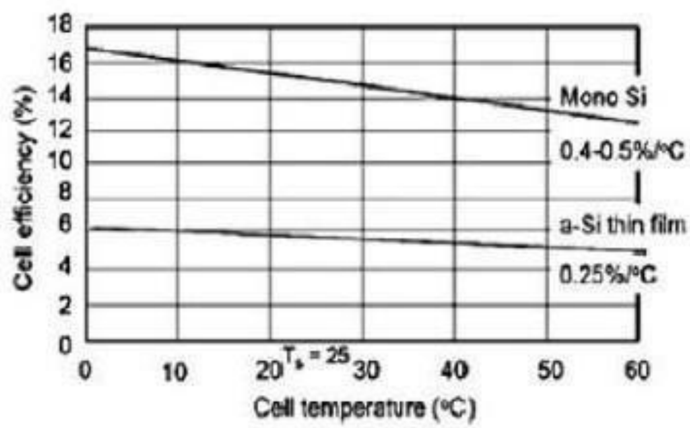


Figure 4.2: The relation between PV cell efficiency and temperature

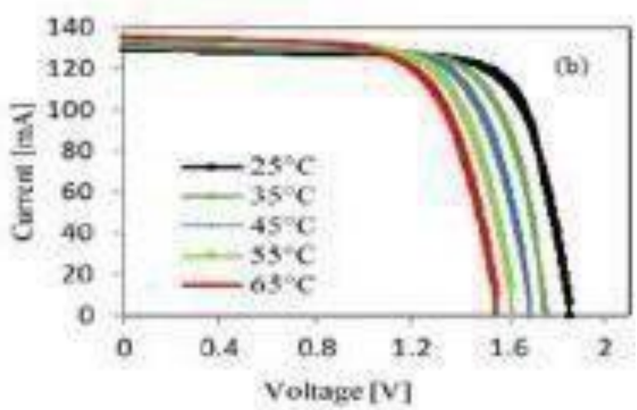


Figure 4.3: Current Vs voltage curves for p-Si

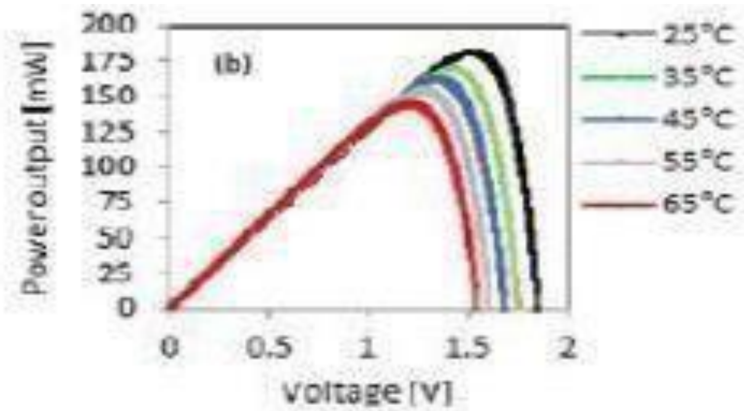


Figure 4.4: Output power Vs voltage curves for (a) p-Si

Output power demonstration of typical poly crystalline PV cells at different temperature

Temperature in Degree	p-Si mW
25	181.5
35	170.1
45	161.5
55	153.4
65	143

The drop in $Pmax$for typical the Polycrystalline solar cells in three regions

Temperature in Degree	p-Si
22-45	-11%
45-65	-11.5%
25-65	-21.2%

For Polycrystalline:
Typical module efficiency –-- 13-16 %
Best research cell efficiency---20.4%
Typical length of warranty---25years
Temperature resistance --- Less temperature resistant than mono
Additional details --- Less silicon waste in the production process

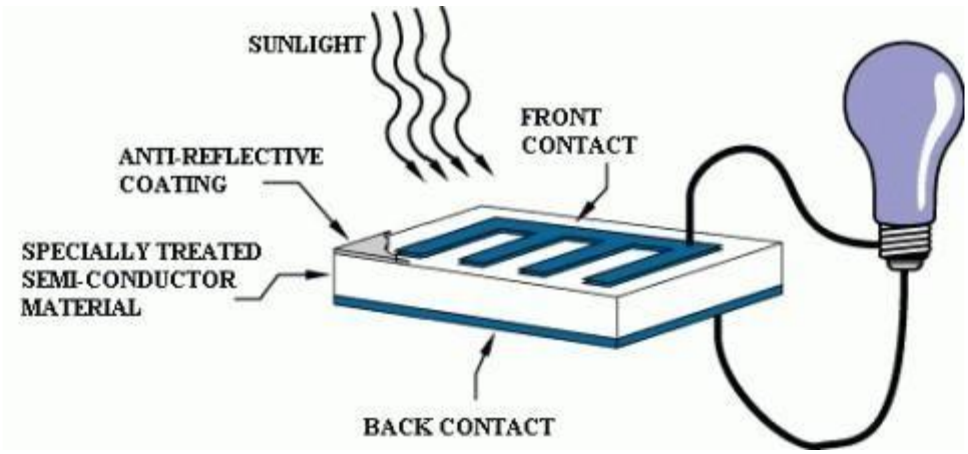


Figure 4.5: Model solar panel system

We have used 3W polycrystalline solar panel because this is the most efficient and available panel for small type power generation purpose. **[17]**

Solar Module Typical Performance Characteristics:

Peak Power:	**3w**
Maximum Power Voltage (Vmp)	**7V**
Maximum Power Current (Imp)	**428mA**
Open Circuit Voltage (Voc)	**8.4A**
Short Circuit (Isc)	**510mA**

STC (Standard Test Condition): AM 1.5 1000W/m 25c

It will cost 300 rupees

Figure 4.6: 3Wp PV Module

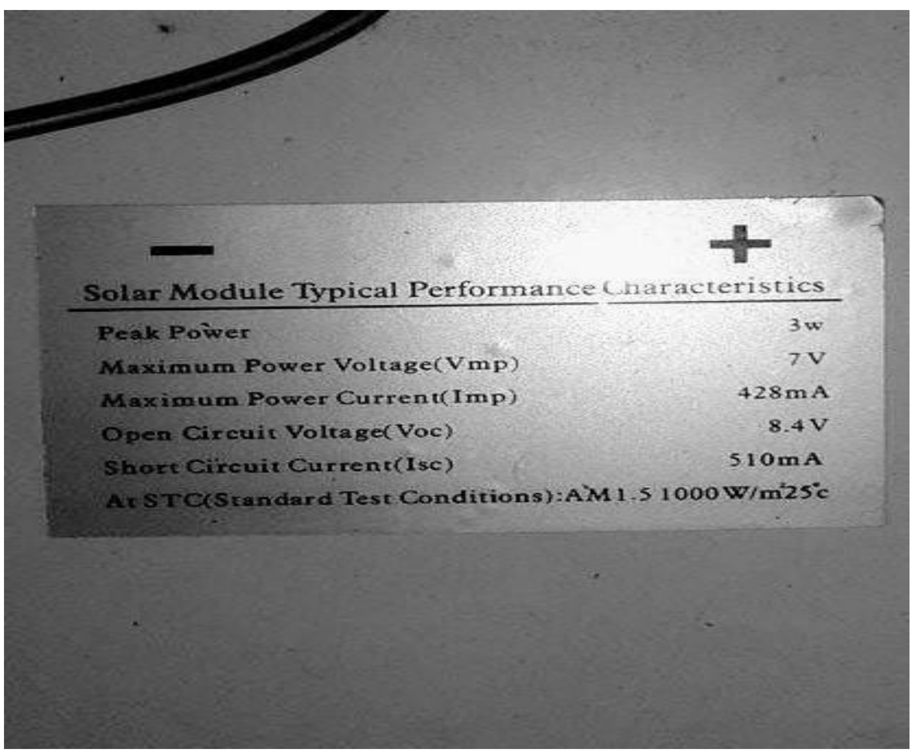


Figure 4.7: Specification of solar panel 3W

TP 4056 Module

We have used TP 4056 in light of the fact that it is an entire steady present/consistent voltage direct charger for single cell lithium-particle batteries. Its SOP package and low external component count make the TP4056 in a perfect world suited for convenient applications. The TP4056 can work inside USB and divider connector. Here no blocking diode is required due to the interior PMOSFET architecture and have avoid to negative Charge Current Circuit. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The TP4056 thus ends the charge cycle when the charge current drops to 1/tenth the customized an incentive after the last buoy voltage is come to. TP4056 different components incorporate current screen, under voltage lockout, programmed revive and two statuses stick to show charge end and the nearness of an info voltage. This tiny module is perfect for charging a single cell 3.7V 1 Ah. It is fine that when you charge a battery, the current (in mA) offered by the breakout board is 37-40% of the battery capacity (in mAh). For example, we used 3000mAh battery capacity to charge the battery we should adjust the resistance in a way that the current offered is approximately 370mA-400mA. This module will help us to protect the study lamp without any problem and damages.

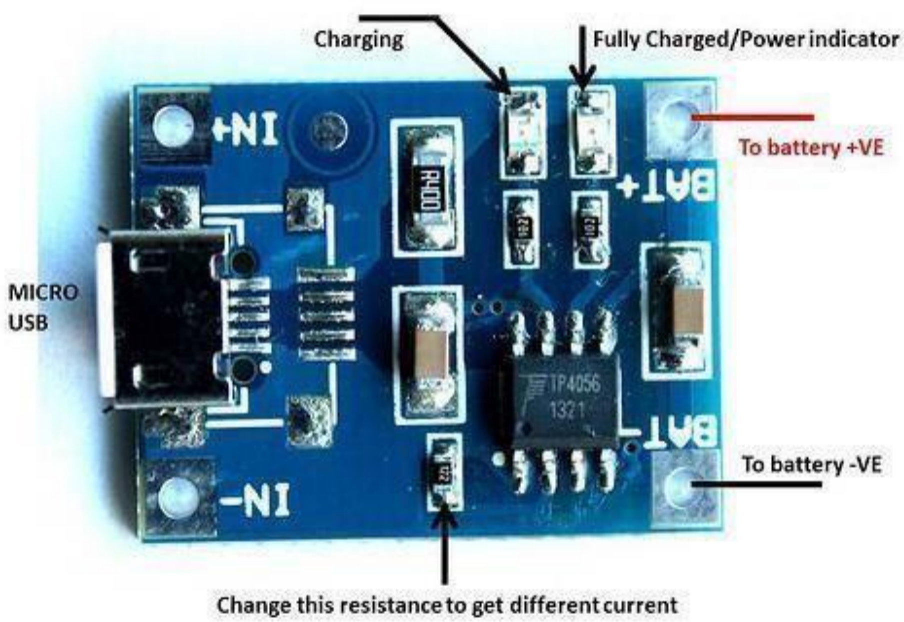


Figure 4.8: TP 4056 Module

Item Name: 5V Mini USB 1A Lithium Battery Charging Board

Charge module: Linear charging

Current: 1A adjustable

Charge precision: 1.5%

Input voltage: 4.5V-5.5V

Full charge voltage: 4.2V

Work temperature: -10℃ to +85℃

Inverse polarity: NO

LED indicator: Red is charging, and GREEN is full charged

Input interface: DC port

Using the Module

- 5V DC from solar panel to pads marked IN+ and IN- on left-hand side of the module
- Connect cell to charge to B+/B- pads on right-hand side of module
- A load (the battery to power) can be connected to the OUT+/OUT- pads on the right-hand side
- Important! Disconnect load when charging
- The red LED indicates changing in progress and green LED indicates charging has finished.
- Should not charge battery at a rate greater than 1C.

4.4.3 Application:

Things we can use to this module are Cellular Telephones, PDAs, GPS ·Charging Docks and Cradles ·Digital Still Cameras, Portable Devices ·USB Bus-Powered Chargers, Chargers

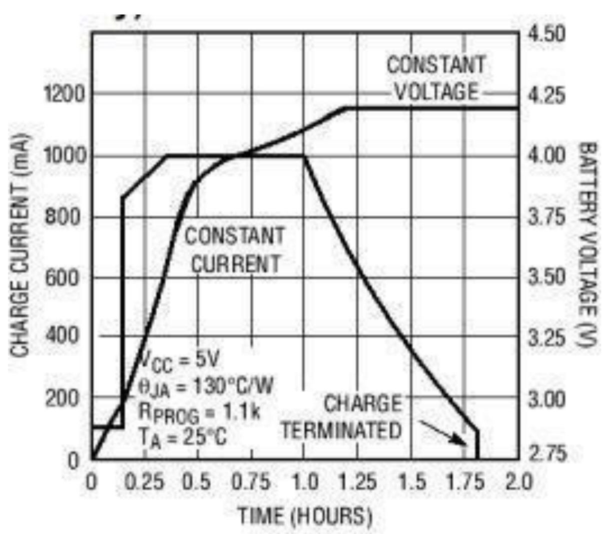


Figure 4.10: Complete Charge Cycle (1000mAh Battery) **[8]**

Charge state	Red LED $\overline{CHRG}$	Greed LED $\overline{STDBY}$
charging	bright	extinguish
Charge Termination	extinguish	bright
Vin too low; Temperature of battery too low or too high; no battery	extinguish	extinguish
BAT PIN Connect 10u Capacitance; No battery	Greed LED bright，Red LED Coruscate T=1-4 S	

Figure 4.11: Indicator light state **[18]**

Use the following table of resistance and current values to solder the right resistor to obtain the required current:

RPROG (k)	IBAT(mA)
30	50
20	70
10	130
5	250
4	300
3	400
2	580
1.66	690
1.5	780
1.33	900

Table 4.1: Various resisters in TP4056

Battery

We have used the lithium iron phosphate ($LiFePO_4$) battery which is also called LFP battery (with "LFP" standing for "lithium Ferro phosphate"), is a type of rechargeable battery which uses $LiFePO_4$ as a cathode material, and a graphitic carbon electrode with a metallic current collector grid as the anode. $LiFePO_4$ batteries have somewhat lower energy density than the more common lithium cobalt oxide ($LiCoO_2$) design found in consumer electronics, but offer longer lifetimes, better power density and are inherently safer. $LiFePO_4$ is finding a number of roles in vehicle and other electrical products use and backup power. Lithium-ion batteries are incredibly popular these days. You can find them in laptops, PDAs, cell phones and iPods. They're so common because, pound for pound, they're some of the most energetic rechargeable batteries available. **[19]**

Why Lithium is used in Batteries?

When electrons flow through a device such as a light bulb, the battery's energy issued to do work. This gives lithium-ion batteries a much better energy per volume ratio–or energy density–than an ordinary alkaline battery or other common rechargeable battery such as a nickel-metal hydride.

How Lithium-ion Batteries Work:

As with most batteries you have an outer case made of metal. The use of metal is particularly important here because the battery is pressurized. This metal case has some kind of pressure-sensitive vent hole. If the battery ever gets so hot that it risks exploding from over-pressure, this vent will release the extra pressure. The battery will probably be useless afterwards, so this is something to avoid. The vent is strictly there as a safety measure. So is the Positive Temperature Coefficient (PTC) switch, a device that is supposed to keep the battery from overheating.

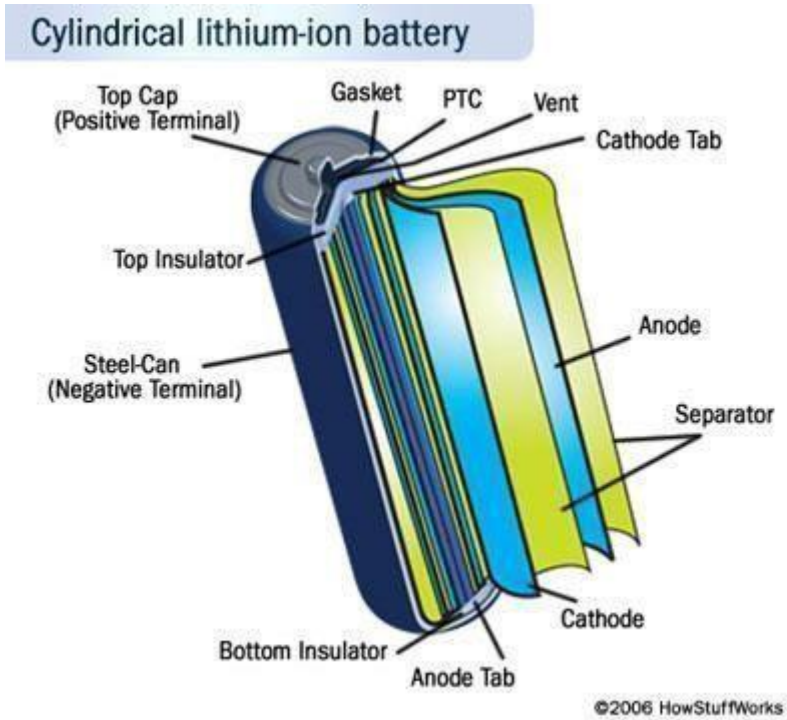


Figure 4.11: Lithium Ferro Phosphate Battery

This metal case holds a long spiral comprising three thin sheets pressed together:

- A Positive electrode
- A Negative electrode
- A separator

Inside the case these sheets are submerged in a natural dissolvable that goes about as the electrolyte. Ether is one normal dissolvable.

Each cell produces 3.7 volts. This is much higher than the 1.5 volts typical of a normal AA alkaline cell that you buy at any market and helps make lithium-ion batteries more compact in small devices. **[20]**

Delivering a Charge:

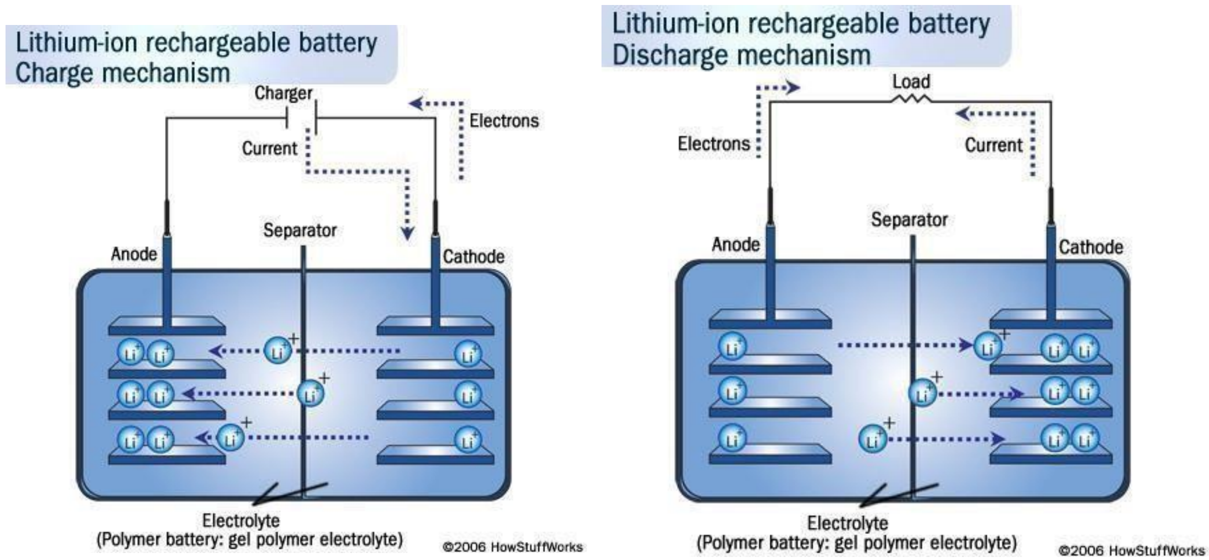


Figure 4.12: Lithium ion battery charging discharging time **[21]**

Today, lithium-molecule batteries are created with affirmations to oblige the charging voltage and to stop the battery if the temperature ends up being too high. Diverse assurances consider venting because of improvement of weight and maintain a strategic distance from too significant discharge, after which the battery can't be restored. This guarded equipment makes the battery safe, in any case it also decreases the division of the battery that is used to store essentialness, and besides slowly exhausts the battery despite when the device is off. Different research groups are in the midst of upgrading these and diverse parts of the lithium-molecule battery, and the future looks splendid for this enduring battery to appear in a consistently expanding number of devices, including the electric cars we hear such an extraordinary sum about these days.

Are Lithium Cobalt Batteries Safe?

Most lithium-ion batteries for portable applications are cobalt-based. The system consists of a cobalt oxide positive electrode (cathode) and a graphite carbon in the negative electrode (anode). One of the main advantages of the cobalt-based battery is its high energy density.

Advantage of Lithium Iron Phosphate (LiFePO4) Battery

Charge- discharge efficiency -- 96%, consistent throughout current range. Rated capacity is based on 20 minute discharge (3C), a one hour or longer discharge will actually give 10% more than the rated capacity.

Temperature resilience – Excellent – ambient temperatures up to 45 degree C will not affect the life of the cell at all.

Quick charging -- Standard time 1.30 hr. So it will be so helpful for charging with solar.

Charging Energy Source Size --- Only about 4% of the energy is lost to heat – big savings in charging energy and capital on PV installations Etc.

Pack capacity -- Pack can be sized to 60% of the “rated” capacity of a lead acid pack because of 96% efficiency and ability to discharge on regular occasion to 80% DOD with much lower effect on life reduction. **[22]**

How Long Do Lithium Ion Batteries Last?

- Lithium ion chemistry prefers partial discharge to deep discharge, so it's best to avoid taking the battery all the way down to zero. Since lithium-ion chemistry does not have a "memory", you do not harm the battery pack with a partial discharge. If the voltage of a lithium-ion cell drops below a certain level, it's ruined.

- Lithium-ion batteries age. They only last two to three years, even if they are sitting on a shelf unused. So if we keep using1 the battery with the thought that the battery pack will last five years. It won't. Also, if you are buying a new battery pack, you want to make sure it really is new.

- Avoid heat, which degrades the batteries.

So we used this lithium iron phosphate for a long survival and as a powerful source of light which will suitable for the studying purpose.

It will cost 150 rupees.

High Power LED

The High Power LED is comparable in brightness with the standard incandescent and halogen light bulbs. This makes the High Power LED perfect for automotive, industrial, home and hobby applications.

Not only are they bright, they also consume a fraction of power of an incandescent bulb making them extremely energy efficient.

Figure 4.13: High Power LED

We have used High Power Led 1WATT 140-160LM. [5]

Specifications:
Material: Aluminum
Size: Customized

Product	Emitted Color	Color temp	IV_(lm)	View Angle	VF_(V)
SL1W-WC(120-140)	Pure White	6000-6500K	120-140lm	140*	3.0-3.6V

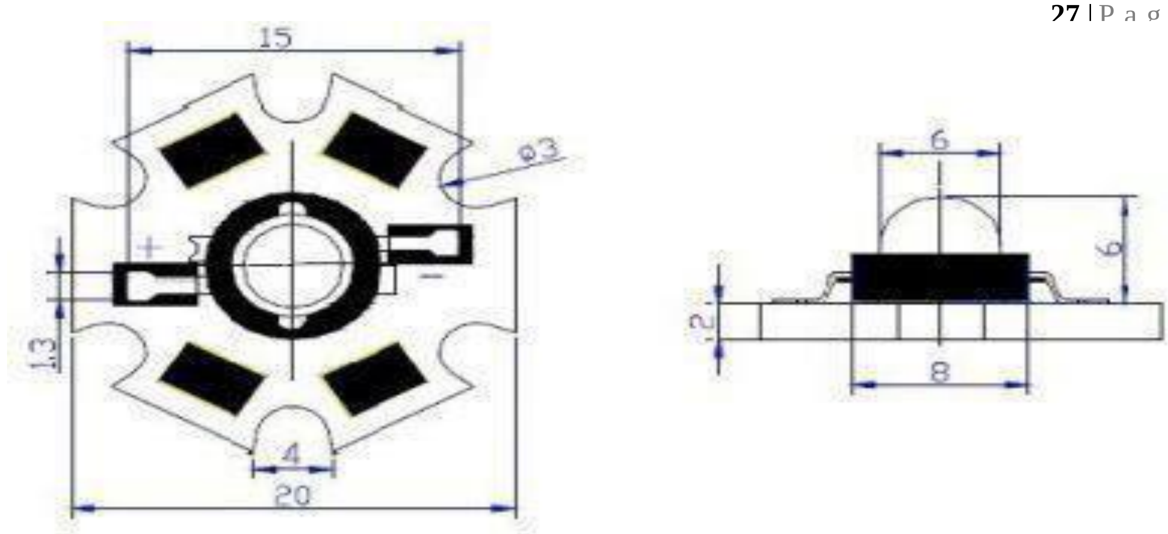


Figure 4.14: specified diagram of high power LED

Basic Advantages of LED Light

Energy efficient - LED's are now capable of giving output of 135 (lumen/watt)

Long Lifetime - 50,000 hours or more if properly engineered

Rugged - LED's are also called "Solid State Lighting (SSL) as they are made of solid material with no filament or tube or bulb to break

No warm-up period - LED's light instantly – in nanoseconds

Not affected by cold temperatures - LED's "like" low temperatures and will startup even in subzero weather

Directional - With LED's you can direct the light where you want it, thus no light is wasted

Excellent Color Rendering - LED's do not wash out colors like other light sources such as fluorescents, making them perfect for displays and retail applications

Environmentally friendly - LED's contain no mercury or other hazardous substances

Controllable - LED's can be controlled for brightness and color **[23]**

Why We Use LED for the Project?

- LEDs would perfect gas to utilization done requisitions that need aid liable on incessant on-off cycling, dissimilar to fluorescent Lights that wear out All the more rapidly At cycled frequently, or HID Lights that require quite a while in front of restarting.
- LEDs could precise effectively be darkened or strobe. LEDs light up extremely rapidly. An ordinary red pointer headed will attain full brilliance clinched alongside microseconds.

- LEDs mostly fail by dimming over time, rather than the abrupt burn-out of incandescent bulbs.
- LEDs could be really little Also need aid effortlessly populated onto printed circlet sheets.
- LEDs don't hold numerous mercury; Dissimilar to conservative fluorescent Lights**. [24]**

Disadvantages and Challenges in Using LEDs

LEDs are at present more costly, cost per lumen, on an underlying capital cost premise, than more other traditional lighting innovations. In any case, while considering the aggregate cost of proprietorship (counting vitality and upkeep costs), LEDs far outperform radiant or halogen sources and start to undermine smaller fluorescent lights. **[25]**

Cost Effective

The Chart Below thinks about various light sources in light of the life of the globule and the electrical cost at 10 pennies for each kWh (kilowatt hour).**[26]**

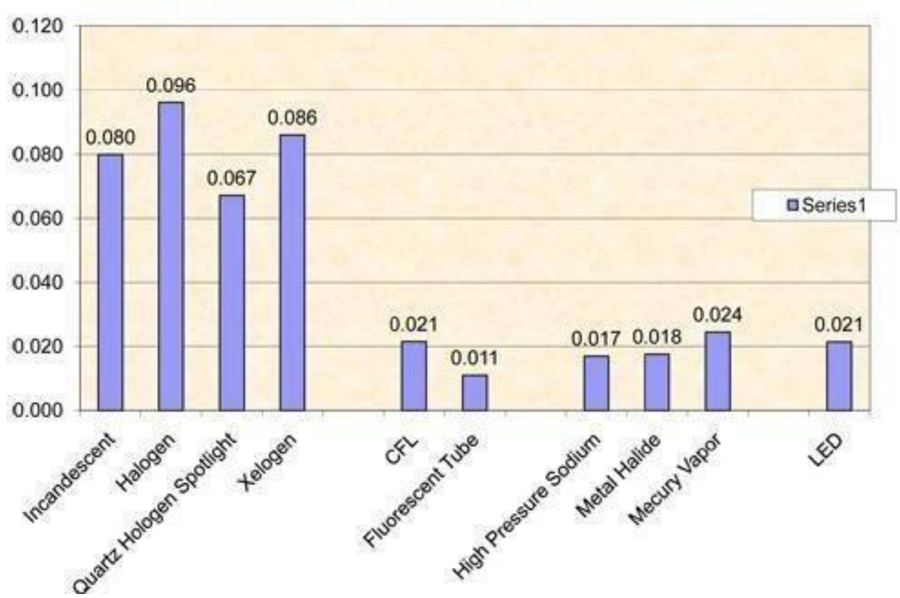


Figure 4.15: Various light sources in light of the life of the globule and the electrical cost **[27]**

Battery Level Indicator

This circuit is used to notify the user that how much charge is left and how long it can serve. We used 3 different resistors 17ohm, 15 ohm, 1k and three led indicator. Different resistors is for different led characters .

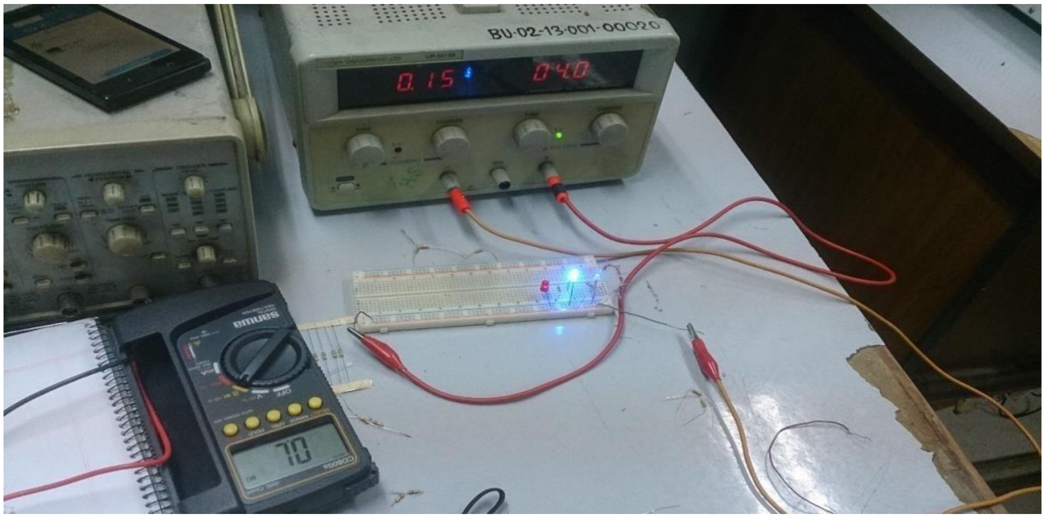


Figure 4.16: at 4 volt the blue light is on

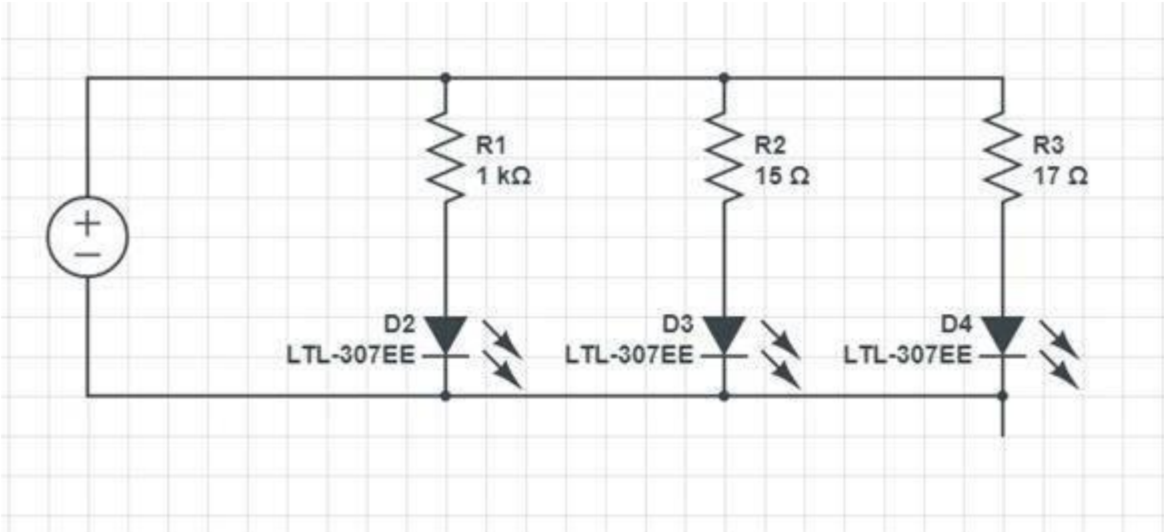


Figure 4.17: Battery indicator circuit

PCB Design

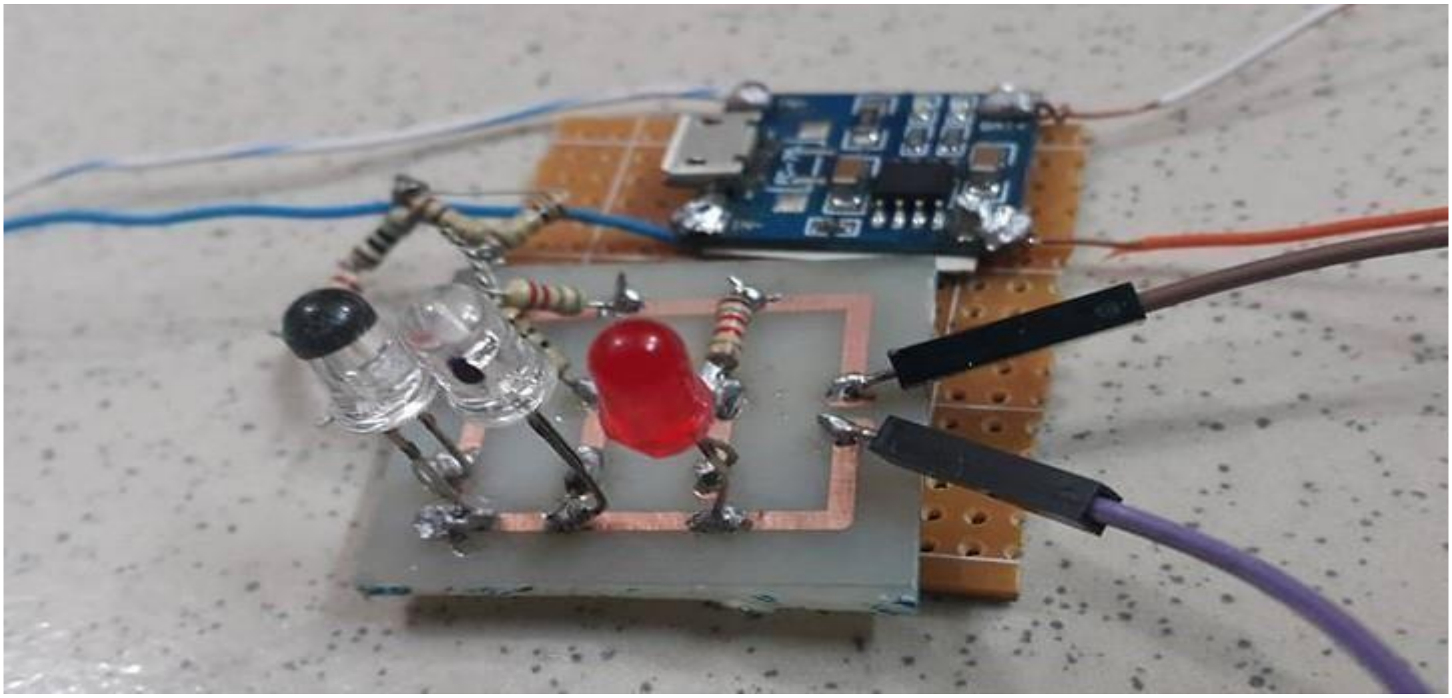


Figure 4.18: PCB of battery level indicator and TP 4506 Module

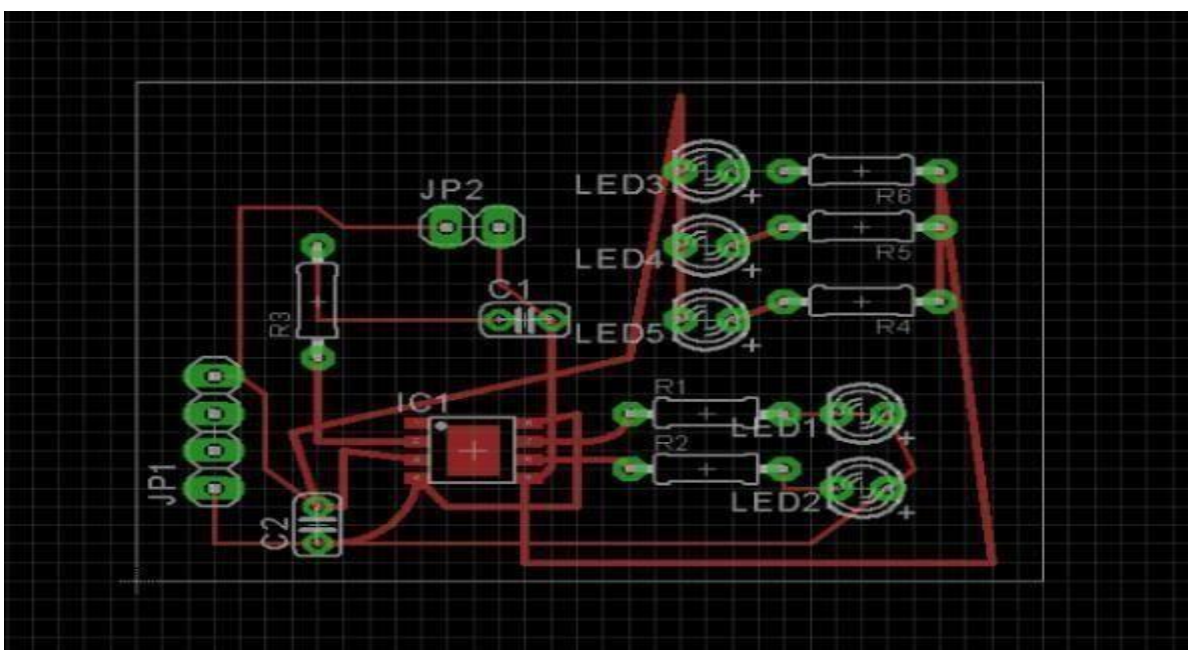


Figure 4.19: PCB design of battery level indicator and TP 4506 Module by EAGLE

Chapter 3

Testing Efficiency and Durability

Selection of LED

For studying purpose and for more light life we have to choose our led light for our solar study lamp. A chart with basic wattage recommendations based on age, type/amount of use, and type of light bulb is given below

	Footcandles	Incandescent	Halogen	Fluorescent	LED
5 - 12 yrs Child's Desk	25 – 50 FC	≤ 40 watts	≤ 20 watts	≤ 9 watts	1-3 watts
13 - 24 yrs Adolescent's Desk	20 – 75 FC	≥ 60 watts	≥ 50 watts	≤ 9 watts	≤ 5 watts
25 – 55 yrs Home Office	35 – 75 FC	≥ 60 watts	≥ 50 watts or 37 watts IR lamp	≤ 9 watts	5-10 watts
50 – 75 yrs Home Office	50 – 100 FC	≥ 100 watts	≥ 50 watts IR lamp	≤ 13 watts	5-10 watts
Reading in Bed	100 FC	–	–	–	3 watts

Table 5.1: LED selection

From the above chart we can choose 1 watt LED for our solar study lamp as it will consume less power and will the desired luminosity for a student.**[27]**

Selection of PV Panel

Firstly you need to know how much energy your battery can store and then select a Solar panel that can replenish your 'stock' of energy in the battery in line with your pattern of use.

There are three main things we considered to choose our Solar panel

- How much energy can our battery store?
- How much energy will our appliance use over a period of time?
- How much energy can a Solar panel generate over a period of time?

Maximum Energy Our Battery Can Store

We know that battery capacity (energy stored in a battery) is measured in watt-hours (Wh)/ kilowatt-hours (kWh)/amp-hours (Ahr).The Equation for getting the energy stores in a battery is given below

Battery size in AH * Battery Voltage = Power available in watt hours

For Our battery the calculation is:

3000mAH * 4V = 12 WH

This justifies that the battery can supply 1w for 12 hours. We have to keep in mind that the more energy we take, the faster the battery discharges. Our minimum required voltage is 2.7V so we can't take all the power from the battery when the battery voltage drops below 2.7V . **[28]**

Energy that Our Appliance Use Over a Period of Time

We know that the power consumption of any electronic device (example: LED light) is given in Watts. To calculate the energy we need to multiply the power consumption by the hours of usage. We are using a LED light which consumes 1W power and we are using it for 8 hours (approximate) .So usage of the LED is

1w * 8 hours per day = 8w per day **[28]**

Solar Panel Size

Our power requirement is 8w per day. From the average of our Data sheet we got that we gets at least 3 hours (minimum) sunlight everyday .we could use this equation below for finding the peak power of our solar panel. **[28]**

Watts required / time of year sunshine hours = panel size

→ 8 / 3 = 2.67W panel

As we can’t get a 2.67W solar panel we used a 3Wsolar panel for this application.

Selecting the right technology:

Solar panel can be classified into 2 categories based on cell structure .they are

- Crystalline silicon
- Amorphous silicon or thin-film

Again The crystalline silicon solar panel can be classified into 2 categories

- Mono-crystalline
- Poly crystalline

The comparison between different types of solar cell technologies are given below

Mono-crystalline	**Poly crystalline**
• Mono-crystalline solar panels have the highest efficiency rates as they are made of highest grade silicon	• polycrystalline silicon is simpler and can be used for household activity
• Performs great in low light	• Performance is not good in low light
• Expensive	• Less expensive

Table 5.2: Selecting the right technology

For making our product cheaper and user friendly we used 3W poly crystalline solar panel. **[29]**

Testing of the Solar Panel

We need to check that our solar panel is working properly, besides we want to know that what output our panel is giving. For this reason we used a multi-meter to measure current and voltage. We got the voltage (V) and current (A) ratings from the back of our panel

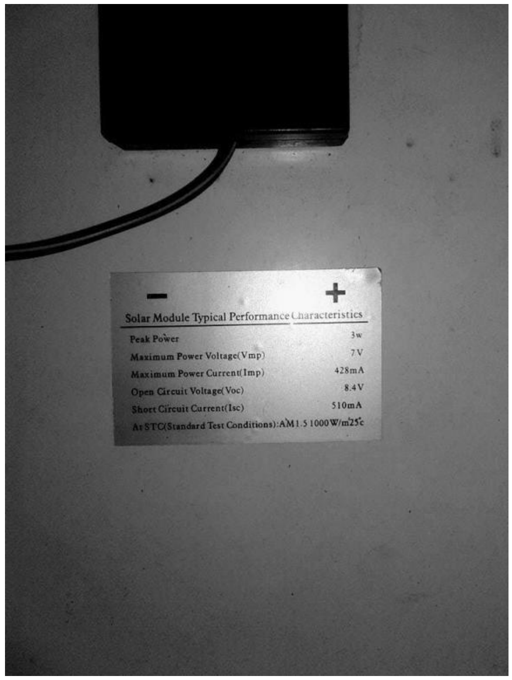


Figure 5.1: Specification of Solar panel

Firstly we checked that sunlight condition is suitable for measuring the rated output from our panel checked for short circuit and the polarities when connecting solar panels

Voc Test

The solar panel was faced to sunlight and set the multi-meter to measure Voltage. We measured the voltage between the +ve and -ve terminals of the panel .sometimes we got the value negative because we have connected the negative contact of the voltmeter to the positive contact of the panel and the positive contact of the voltmeter to the negative contact of the panel.

Figure 5.2: Voc Test

Isc Test

For measuring short circuit current we set the multi-meter at10A (for safety) at least to start with. You can change the setting later if required. Here we also got negative results sometimes as we have connected the negative contact of the voltmeter to the positive contact of the panel and the positive contact of the voltmeter to the negative contact of the panel.

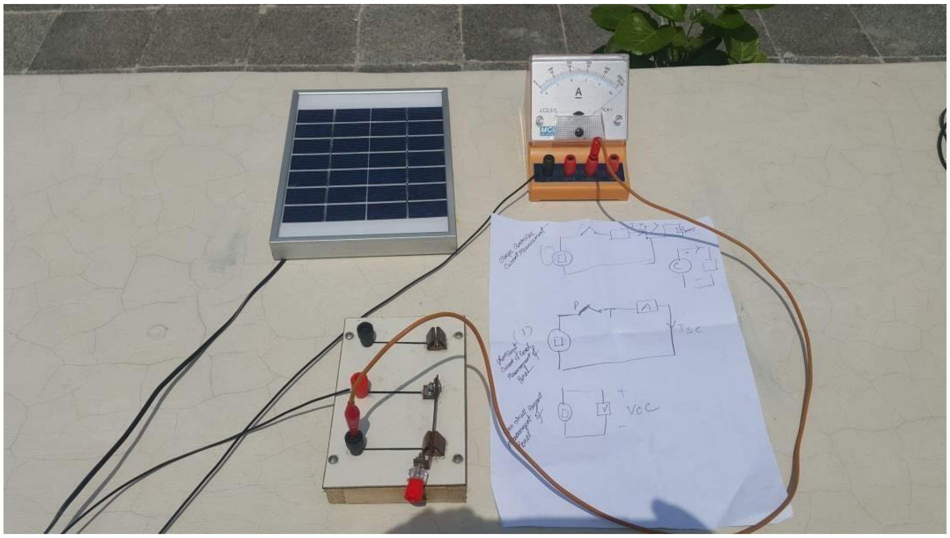


Figure 5.3: Isc Test

Battery Charging Operation

For battery charging we used the circuit below, besides solar power we can work with USB and wall Adapter by this charge controller circuit. For this circuit no blocking diode is required because we used a PMOSFET internally to demolish negative charge current. The output voltage is fixed at 4.1V

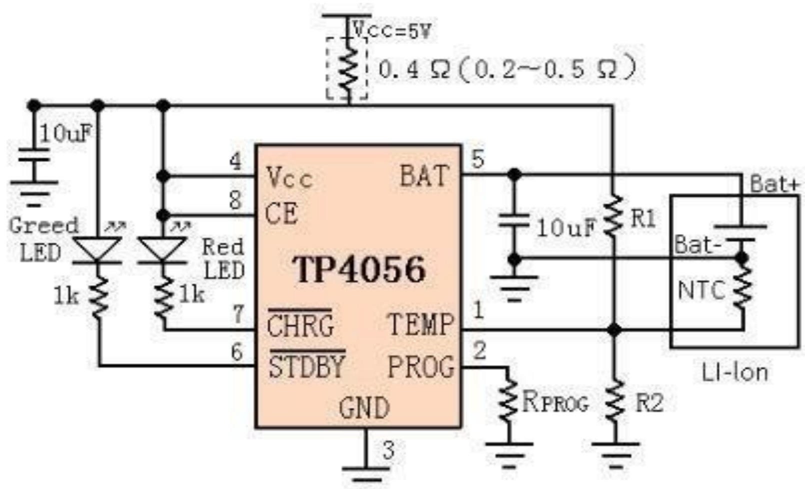


Fig5.2:TP4056 module

After connecting the circuit with our solar panel blue light shows up that means the circuit is ready to charge the battery. By using multi meter we measured the open circuit voltage of the circuit and we got the exact same value 4.1V. When we connected the battery the red light shows up that means the circuit is in charging period. If the battery is fully charged the blue light again turns on. When disconnecting the solar panel, charge controller and battery we disconnected the panel from the charge controller first then disconnected the charge controller from the battery. For avoiding damage we connect the charge controller to the battery first and then connected to the solar panel.

However, we have tried to keep the battery operating voltage of its 80% as it maintains the healthy battery condition. The backup time we have fixed from the survey, now we have also met that requirement properly.

Battery Discharging Operation

Battery starts discharging when Led light is turned on. The fully discharge voltage is 1.7v at that point the led gives no light. From our data sheet we got that 2.7v is the minimum point as the light intensity goes down.

DISCHARGE TIME	USABLE LIGHT	BAT VOLT	
		CONTCT	LED CONNECTED
11pm-12am	3.24v-2.7v	3.24	3.15
10.41pm-10.30am	3.80v-2.62v	3.69	3.6
8pm-3.30am	3.94v-2.7v	3.94	3.85
9pm-4pm	3.98v-2.7v	3.98	3.88
10pm-2pm	3.97v-2.7v	3.97	3.88
6pm-8pm	3.4v-2.7v	3.4	3.31
6.30pm-8pm	3.2v-2.7v	3.2	3.11
9pm-4pm	3.78-2.7	3.78	3.71

Table 5.2: Battery discharging time

From the voltage level indicator we can see the discharge of the battery .when the battery is fully charged all led will glow. When 15% of the battery is discharged due to usage of the power for the study lamp the first led shuts down and the second led goes down when 25% battery is discharged. For safety purpose we should not use the lamp when only the red led is on. Because the more battery is discharged the more time it will take to charge fully and will decrease the life time of the battery.

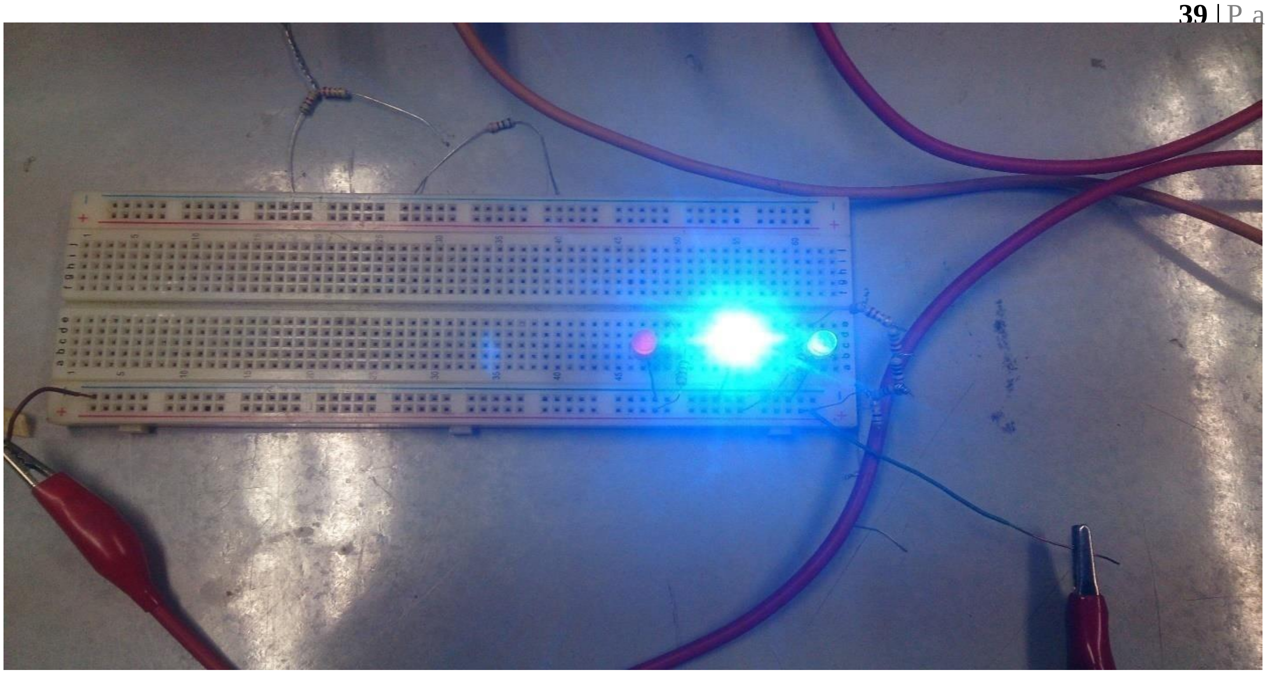


Figure 5.3: Active voltage indicator

Safety Check:

For any circuit we need to check that if the circuit is safety or not. For this reason we can take some steps of checking

- Checked for any kind of short circuit took place in the power path
- verified the circuit wiring is correct
- Checked all the connections for good electrical contact

Cost Analysis

The overall goal was building a low cost portable solar study lamp, with a better efficiency and long durability. After overall cost analysis of individual components in local market we found out the total product cost which is 680.

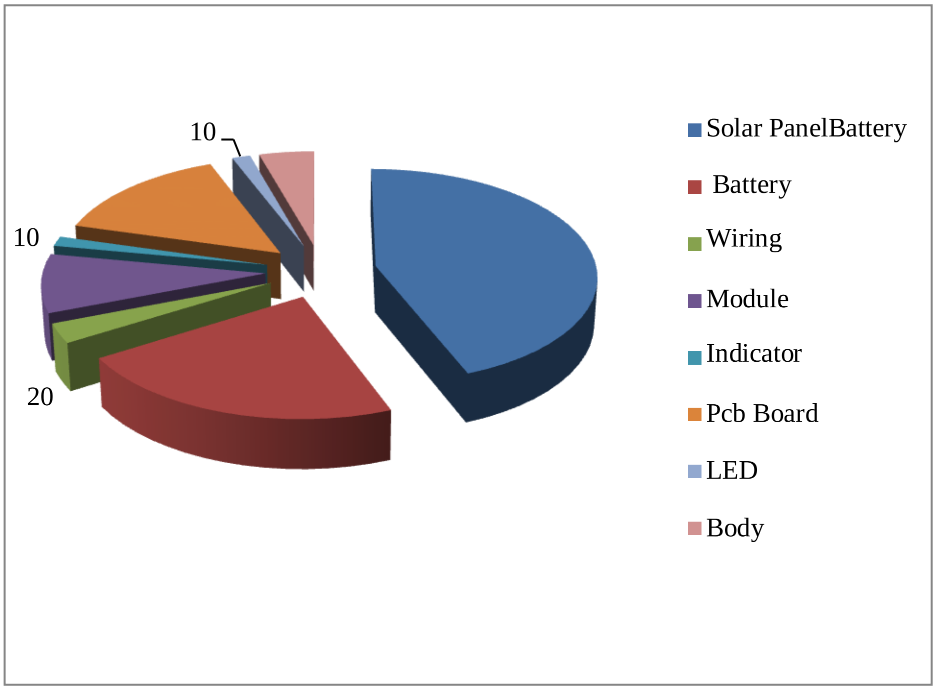


Fig5.4: Cost structure of final design

Total cost of the final product is 680 rupees

Economical Analysis

However, though the interviewed family's monthly cost for lighting is 233 Rs, yearly their cost will be 233*12=2,796 Rs,where one unit solar study lamp costing 680 Rs only. The product we assume will last at least one year. So, it is clear thatpeople can save 2,116 per year including more safety and environment friendly independent source of lighting.

Chapter 4

Conclusion

Conclusion:

This thesis paper is based on a practical calculation to identify a small problem and building a cost efficient solar study lamp for the lower income family children of India who are deprived of minimum lightening for their education. India is lacking continuous supply of power from national grid connection especially in rural and remote areas and during summer season it increases the more.

Future Work:

There are plenty of scopes for improvements in near future which can make it more efficient with more light weight, adding more features like mobile charging , as a power bank and with more beautiful design. Moreover, better design with more efficiency can be the best option in near future. Besides energy crisis is increasing day by day in India and in rural areas the situation is already pretty bad. So, it's a very small initiative to facilitate continuous education for at least 6 hours to help our rural area students. In larger scale with governments support or other donated fund, it can solve the problem forever cause solar energy is clean and renewable and ecofriendly.

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TP4056 1A Standalone Linear Li-Ion Battery Charger with Thermal Regulation in SOP-8

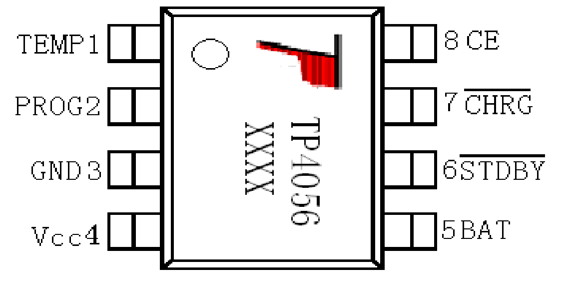
DESCRIPTION

The TP4056 is a complete constant-current/constant-voltage linear charger for single cell lithium-ion batteries. Its SOP package and low external component count make the TP4056 ideally suited for portable applications. Furthermore, the TP4056 can work within USB and wall adapter. No blocking diode is required due to the internal PMOSFET architecture and have prevent to negative Charge Current Circuit. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The TP4056 automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached.
TP4056 Other features include current monitor, under voltage lockout, automatic recharge and two status pin to indicate charge termination and the presence of an input voltage.

FEATURES

- Programmable Charge Current Up to 1000mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Complete Linear Charger in SOP-8 Package for Single Cell Lithium-Ion Batteries
- Constant-Current/Constant-Voltage
- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Preset 4.2V Charge Voltage with 1.5% Accuracy
- Automatic Recharge
- two Charge Status Output Pins
- C/10 Charge Termination
- 2.9V Trickle Charge Threshold (TP4056)
- Soft-Start Limits Inrush Current
- Available Radiator in 8-Lead SOP Package, the Radiator need connect GND or impending

PACKAGE/ORDER INFORMATION



SOP—8

photo	ORDER PART NUMBER TP4056-42-SOP8-PP
	**PART MARKING** TP4056

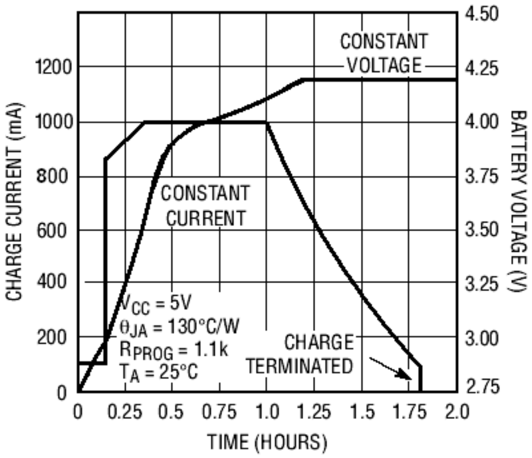
ABSOLUTE MAXIMUM RATINGS

- Input Supply Voltage(V_{CC})：-0.3V～8V
- TEMP：-0.3V～10V
- CE：-0.3V～10V
- BAT Short-Circuit Duration：Continuous
- BAT Pin Current：1200mA
- PROG Pin Current：1200uA
- Maximum Junction Temperature：145℃
- Operating Ambient Temperature Range：-40℃～85℃
- Lead Temp.(Soldering, 10sec)：260℃

APPLICATIONS

- Cellular Telephones, PDAs, GPS
- Charging Docks and Cradles
- Digital Still Cameras, Portable Devices
- USB Bus-Powered Chargers,Chargers

Complete Charge Cycle (1000mAh Battery)



TEMP(Pin 1) :Temperature Sense Input Connecting TEMP pin to NTC thermistor's output in Lithium ion battery pack. If TEMP pin's voltage is below 45% or above 80% of supply voltage V_{IN} for more than 0.15S, this means that battery's temperature is too high or too low, charging is suspended. The temperature sense function can be disabled by grounding the TEMP pin.

PROG(Pin 2): Constant Charge Current Setting and Charge Current Monitor Pin charge current is set by connecting a resistor R_{ISET} from this pin to GND. When in precharge mode, the ISET pin's voltage is regulated to 0.2V. When in constant charge current mode, the ISET pin's voltage is regulated to 2V.In all modes during charging, the voltage on ISET pin can be used to measure the charge current as follows:

$$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \times 1200 \quad (V_{PROG}=1V)$$

GND(Pin3): Ground Terminal

Vcc(Pin 4): Positive Input Supply Voltage V_{IN} is the power supply to the internal circuit. When V_{IN} drops to within 30mv of the BAT pin voltage, TP4056 enters low power sleep mode, dropping BAT pin's current to less than 2uA.

BAT(Pin5): Battery Connection Pin. Connect the positive terminal of the battery to BAT pin. BAT pin draws less than 2uA current in chip disable mode or in sleep mode. BAT pin provides charge current to the battery and provides regulation voltage of 4.2V.

$\overline{STDBY}$(Pin6): Open Drain Charge Status Output When the battery Charge Termination, the $\overline{STDBY}$ pin is pulled low by an internal switch, otherwise $\overline{STDBY}$ pin is in high impedance state.

$\overline{CHRG}$ (Pin7): Open Drain Charge Status Output When the battery is being charged, the $\overline{CHRG}$ pin is pulled low by an internal switch, otherwise $\overline{CHRG}$ pin is in high impedance state.

CE(Pin8): Chip Enable Input. A high input will put the device in the normal operating mode. Pulling the CE pin to low level will put the YP4056 into disable mode. The CE pin can be driven by TTL or CMOS logic level.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at **T_A=25℃ , V_{CC} =5V**，unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CC}	Input Supply Voltage		●	4.0	5	8.0	V
I_{CC}	Input Supply Current	Charge Mode, R_{PROG} = 1.2k StandbyMode(Charge Terminated) Shutdown Mode (R_{PROG} Not Connected, V_{CC} < V_{BAT}, or V_{CC} < V_{UV})	● ● ●		150 55 55	500 100 100	µA µA µA
V_{FLOAL}	Regulated Output (Float) Voltage	0℃≤T_A≤85℃，I_{BAT}=40mA		4.137	4.2	4.263	V
I_{BAT}	BAT Pin Current Text condition:VBAT=4.0V	RPROG = 2.4k, Current Mode RPROG = 1.2k, Current Mode Standby Mode, V_{BAT} = 4.2V	● ● ●	450 950 0	500 1000 −2.5	550 1050 −6	mA mA µA
I_{TRIKL}	Trickle Charge Current	V_{BAT}<V_{TRIKL}, R_{PROG}=1.2K	●	120	130	140	mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{PROG}=1.2K, V_{BAT} Rising		2.8	2.9	3.0	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	R_{PROG}=1.2K		60	80	100	mV
T_{LIM}	Junction Temperature in Constant Temperature Mode				145		℃

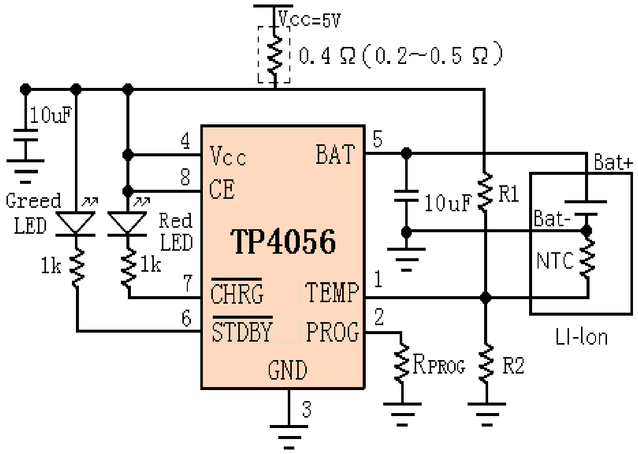
indicator light state

Charge state	Red LED CHRG	Greed LED STDBY
charging	bright	extinguish
Charge Termination	extinguish	bright
Vin too low; Temperature of battery too low or too high; no battery	extinguish	extinguish
BAT PIN Connect 10u Capacitance; No battery	Greed LED bright，Red LED Coruscate T=1-4 S	

Rprog Current Setting

RPROG (k)	I_{BAT} (mA)
10	130
5	250
4	300
3	400
2	580
1.66	690
1.5	780
1.33	900
1.2	1000

TYPICAL APPLICATIONS



SEMICONDUCTOR CORPORATION