RENEWABLE ENERGY LAMP AS AN ALTERNATIVE TO KEROSENE LAMP USED IN RURAL HOUSE HOLDS

Haritha Sameera Jayawickrama

(128324E)

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Department of Electronics & Telecommunication Engineering

University of Moratuwa
Sri Lanka.

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DECLARATION

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Name of the supervisor: Prof S.R. Munasinghe

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Abstract

Keywords: Renewable energy, Sustainable development, Batteries, Electrical products, Consumer products

According to UN Foundation there were 600 million people without access to grid power in 2014. As a result quality of living is in very low level among those people. There for they can’t compete with other communities to improve their social and economic level.

New renewable energy lamp was built for benefit of these under developed communities. This lamp was a miniature construction of an energy grid. This lamp can be energized with Solar, Wind or Hydro energy. This is affordable even for rural people.

The lamp has a 1W LED powered by 2-cell, 300mAh lead acid battery. Suns’ energy is harvested by 5W solar panel. This lamp can light a medium size room for 4 hours. This paper was published in ieeeXplore digital library in December, 2014.

DEDICATION

To my Parents, Brother and Teachers

ACKNOWLEDGEMENTS

Lot of request were heard from all over the world regarding their energy issues. This was a humble effort to convert our traditional commodities to our modern requirements. Final outcome of the project was a replacement for traditional kerosene lamp.

First I would like to thank Dr. Rohan Munasinghe for his valuable advices. He gave lot of engineering solutions to avoid problems we met during lamp development.

Then I would like to thank Dr. (Ms) R.K. De Alwis for her kind advices. She gave lot of valuable managerial solutions for challenges we met during product design.

Then I would like to thank SolarWorld Americas Inc, for their support. They provided me a solar panel.

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CHAPTER 1
INTRODUCTION

Lamp which uses clean energy to power a LED was built as an alternative to kerosene lamp in this project. Traditional kerosene lamp has certain weak features. This lamp was built to solve certain weaknesses of traditional method. Lamp was designed to build and operate in minimum cost.

Kerosene lamp has certain weak features. It has an oil filled bottle which can initiate hazardous fires when combined with it's flame. There are lot of victims due to kerosene lamp accidents. Government has to do a huge investment to reestablish fire victims. Patients had to suffer from painful wounds and had to take lots of pain killers. Fire doesn't know the meaning of infants so that they may also be victims of fire disasters.

Crude oil is a limited resource and takes millions of years to form it from animal substances. Crude oil is available in limited locations on earth surface. Kerosene oil is obtained from crude oil at oil refineries. Chemicals obtained from crude oil is used as a raw material to manufacture synthetic rubber, paints, lubricants, plastics, automobile parts, medicine and synthetic rubber. There fore we have to limit the use of hydrocarbons for lighting to preserve it for future requirements.

Kerosene oil is burned incompletely in lamps to produce light. Fossil fuel burning process creates greenhouse gasses such as Carbon Monoxide, Carbon Dioxide. Sea level rises due to this, and certain islands in the ocean will sunk in the sea. This will lead to bad social situation. There fore green house gas emission to atmosphere should be minimized to prevent this dangerous incident.

Fuel is burned in kerosene lamps to produce light. Kerosene oil is consumed in lamps so that it has an inherent operation cost. In this project electric system was used to produce light. Solar energy is stored in a battery, this stored energy is then used in night for lighting. Fuel cost is saved due to electric circuit. There fore this lamp has a considerably small operation cost.

People work in day time for their objectives. They work for earn, and they do their studies to improve their carrier. People work mostly when light is available.

Active time can be extended with an artificial light. This lamp produces light in a small expense so that people can add more usable time to their life.

A renewable energy lamp was designed as an alternative to traditional kerosene lamp in this project. A rooftop solar panel charges indoor lamp in day time. This battery is used in day time to illuminate a common size room for four hours. Lamp was given the shape of traditional lamp to preserve the tradition and expedite the popularization.

CHAPTER 2

THEORY

Solar Panels.

Solar panels absorb the sunlight as a wellspring of essentialness to deliver power or warmth.

A photovoltaic (PV) module is a packaged, interface get together of regularly 6x10 photovoltaic sun fueled cells. Photovoltaic modules constitute the photovoltaic panels of a photovoltaic system that makes and supplies sun arranged power in business and private applications. Each module is assessed by its DC yield control under standard test conditions (STC), and regularly keeps running from 100 to 365 Watts (W). The viability of a module chooses the area of a module given the same assessed yield – a 8% capable 230 W module will have twofold the zone of a 16% gainful 230 W module. A photovoltaic structure frequently consolidates an assortment of photovoltaic modules, an inverter, a battery pack for limit, interconnection wiring, and on the other hand a solar tracking system.

Photovoltaic modules use light essentialness (photons) from the Sun to make power through the photovoltaic effect. The assistant (stack passing on) individual from a module can either be the top layer or the back layer. Cells ought to in like manner be protected from mechanical mischief and sogginess. Most modules are rigid, yet semi-flexible ones are available, in perspective of thin-film cells. The cells must be related electrically in array plan, to each other.

Modules electrical affiliations are made in grid plan to fulfill for yield voltage or possibly in parallel to give a desired current capacity. The main wires that take the current off the modules may contain silver, copper or other non-magnetic conductive advance metals. Bypass diodes may be intertwined or used remotely, if there ought to emerge an event of inadequate module shading, to maximize the yield of module ranges still illuminated.

Some phenomenal sun based PV modules consolidate concentrators in which light is locked in by central focuses or mirrors onto smaller cells. This engages the use of cells with a high cost for each unit area, (for instance, gallium arsenide) in a fiscally insightful manner.

Ground mounted photovoltaic system are ordinarily tremendous, utility-scale solar power plants. These solar modules are held set up by racks or edges that are affixed to ground based mounting supports. Ground based mounting supports include.

- Shaft mounts, which are driven particularly into the ground or introduced in concrete.
- Foundation mounts, for instance, strong pieces or poured footings.
- Ballasted adjust mounts, for instance, concrete or steel bases that use weight to secure the sun based module system in position and don't require ground entrance.

Housetop mounted sun arranged power structures contain sun based modules held set up by racks or edges associated with roof based mounting supports. Roof-based mounting reinforces include.

- Post mounts, which are joined particularly to the housetop structure and may use additional rails for attaching the module racking or plots.
- Roof mounts, for instance, bond or steel bases that usage weight to secure the board system in position and don't require through passageway.
- All wiring interfacing adjacent daylight based modules to the energy gathering equipment must be presented by close-by electrical codes and should be continue running in a channel suitable for the environment conditions.

Sun controlled trackers increase the measure of energy made per module at a cost of mechanical versatile quality and necessity for help. Alternatively, settled racks hold modules stationary as the sun moves over the sky. The settled rack sets the time when the module is held. Tilt guides proportionate toward a foundation's extension are typical. Panels that face West or East may give fairly cut down energy, yet levels out the supply, and may give more power in the peak demand.

Fig 1. Solar Panels

Hydro Power

Hydropower or water control is control gotten from the energy of falling water or snappy running water, which may be saddled for important purposes. Since old conditions, hydropower from various sorts of watermills has been used as a reasonable power hotspot for water framework and the operation of various mechanical contraptions, for instance, sawmills, material production lines, trip hammers, dock cranes, nearby lifts, and metal plants. A trompe, which produces pressed air from falling water, is every so often used to control other equipment at a distance.

In the late nineteenth century, hydropower transformed into a hotspot for delivering power. In 1881, street lights in the city of Niagara Falls were controlled by hydropower.

Overall associations, for instance, the World Bank see hydropower as a techniques for money related progression without adding liberal measures of carbon to the atmosphere, however dams can have significant negative social and normal impacts.

Fig 2. A small Hydro Power station

Wind Power

Wind control is the usage of twist current through breeze turbines to mechanically control generators for electric power. Wind control, as a differentiating alternative to expending oil subordinates, extensively circled, clean, conveys no ozone exhausting substance transmissions in the midst of operation, eats up no water, and uses little land. The net effects on the earth are far less precarious than those of nonrenewable influence sources.

Wind farms involve various individual breeze turbines which are related with the electric power transmission mastermind. Offshore breeze is steadier and more grounded than aground, and toward the ocean estates have less visual impact, however advancement and bolster costs are fundamentally higher. Minimal inland breeze residences can support some energy into the cross section or give electric vitality to isolated off-grid locations.

Wind control gives variable power which is to a great degree dependable from year to year yet which has enormous assortment over shorter time scales. It is along these lines used as a piece of conjunction with other electric power sources to give a strong supply. Power organization frameworks, for instance, having excess point of confinement, geographically scattered turbines, dispatch able help sources, sufficient hydroelectric power, exchanging and acquiring vitality to neighboring zones, or diminishing interest when wind creation is low, can generally speaking overcome these problems. what's more, atmosphere assessing gifts the electric power framework to be set up for the expected assortments in progress that occur.

Fig 3. A small wind Power station

Battery Chargers.

A battery charger, or recharger, is a contraption used to put energy into a secondary cell or rechargeable battery by passing an electric current through it. The charging tradition (how much voltage or current for to what degree, and what to do while charging is done, for instance) depends upon the size and sort of the battery being charged. Some battery sorts have high versatility for conning (i.e., continued charging after the battery has been totally charged) and can be empowered by relationship with a reliable voltage source or an enduring current source, dependent upon battery sort. The charger may have temperature or voltage distinguishing circuits and a microchip controller to safely alter the charging current and voltage, choose the state of charge, and cut off toward the complete of charge.

A stream charger gives a tolerably little measure of present, adequately just to kill self-arrival of a battery that is sit out of apparatus for a long time. Direct battery chargers may take a couple of hours to complete a charge, high-rate chargers may restore most point of confinement essentially speedier, yet high rate chargers can be more than some battery sorts can persevere. Such batteries require dynamic seeing of the battery to shield it from swindle.

Charge and discharge rates are frequently demonstrated as C or C-rate, which is a measure of the rate at which a battery is accused or discharged of regard to its capacity. Everything considered the C-rate is described as the charge or discharge current isolated by the battery's capacity to store an electrical charge. The C-rate is never negative, so whether it portrays a charging or discharging system depends upon the particular situation.

For example, for a battery with a farthest point of 500 mAh, a discharge rate of 5000 mA (i.e. 5 A) looks at to a C-rate of 10 (consistently), suggesting that such a current can discharge 10 such batteries in a hour. In like way, for a comparative battery a charge current of 250 mA analyzes to a C-rate of 1/2 (consistently), inferring that this present will manufacture the state of charge of this battery significantly in one hour.

Since the unit of the C-rate is typically recommended, some care is required with its documentation to keep away from mixing up it for the battery's capacity to store a charge, which in the SI has unit coulomb with unit picture C. In case both the (dis)charge current and as far as possible in the C-rate extent is expanded by the battery voltage, the C-rate transforms into an extent of the (dis)charge vitality to the battery's energy confine. For example, when the 100 kWh battery in a Tesla Model S P100D is encountering supercharging at 120 kW the C-rate is 1.2 (consistently) and when that battery passes on its most extraordinary vitality of 451 kW, its C-rate is 4.51 (consistently).

High C-rates, 1 consistently or higher, generally require the charger to carefully screen battery parameters, for instance, terminal voltage and temperature to hinder swindling and damage to the cells. Such high charging rates are possible just with some battery sorts. Others will be hurt or possibly overheat or burst into flames. Some may even explode. For example, an auto SLI (starting, lighting, begin) lead-destructive battery passes on a couple of risks of impact.

What practices are best depend upon the kind of battery. NiCd cells must be totally discharged on occasion, or else the battery loses confine after some time on account of a situation known as "memory affect". Once every month (once every 30 charges) is now and again recommended. This extends the life of the battery since memory affect is foreseen while avoiding full charge cycles which are known to be troublesome for an extensive variety of dry-cell batteries, over the long haul realizing an enduring decrease in battery constrain.

Most present day telephones, versatile workstations, and most electric vehicles use Lithium-molecule batteries. These batteries last longest if the battery is sometimes charged. Totally discharging them will spoil their capacity for the most part quickly. When securing in any case, lithium batteries degenerate more while totally charged than if they are only 40% charged. Essentially as with all battery sorts, defilement in like manner happens snappier at higher temperatures. Defilement in lithium-molecule batteries is caused by an extended inward battery resistance due to cell oxidation. This decays the efficiency of the battery, realizing less net current open to be drawn from the battery. However, if Li-ION cells are discharged underneath a particular voltage a substance reaction happens that make them dangerous if empowered, which is the reason in all likelihood every single such battery in customer stock now have an "electronic circuit" that forever impairs them if the voltage falls underneath a set level. The electronic wire draws a little measure of current from the battery, which suggests that if a convenient PC battery is left for a long time without charging it, and with a low basic state of charge, the battery may be forever annihilated.

Motor vehicles, for instance, vessels, RVs, ATVs, bicycles, automobiles, trucks, and more use lead– destructive batteries. These batteries use a sulfuric destructive electrolyte and can generally be charged and discharged without demonstrating memory affect, however sulfating (a compound reaction in the battery which stores a layer of sulfates on the lead) will occur after some time. Normally sulfated batteries are fundamentally supplanted with new batteries, and the old ones reused. Lead– destructive batteries will experience altogether longer life when an upkeep charger is used to "skim charge" the battery. This keeps the battery from frequently being underneath 100% charge, shielding sulfate from forming. True blue temperature compensated float voltage should be used to achieve the best results.

Fig 4. Lead-Acid Battery

Light Emitting Diode

A light-Emitting diode (LED) is a two-lead semiconductor light source. It is a p– n convergence diode that produces light when activated. When a sensible voltage is associated with the leads, electrons can recombine with electron openings inside the contraption, releasing energy as photons. This effect is called electroluminescence, and the shade of the light (contrasting with the energy of the photon) is directed by the energy band opening of the semiconductor. LEDs are nearly nothing (under 1 mm^2) and facilitated optical portions may be used to shape the radiation pattern.

Appearing as realistic electronic parts in 1962, the soonest LEDs released low-constrain infrared light. Infrared LEDs are still a significant part of the time used as transmitting segments in remote-control circuits, for instance, those in remote controls for a wide variety of client equipment. The principle unmistakable light LEDs were similarly of low power and compelled to red. Display day LEDs are available over the discernible, splendid, and infrared wavelengths, with high brightness.

Early LEDs were frequently used as marker lights for electronic contraptions, supplanting minimal splendid globules. They were soon packaged into numeric readouts as seven-part appears and were routinely seen in electronic timekeepers. Late headways have made LEDs proper for common and undertaking lighting. LEDs have incited new shows and sensors, while their high trading rates are important in bleeding edge exchanges advancement.

LEDs have many purposes of enthusiasm over brilliant light sources, including lower imperativeness use, longer lifetime, upgraded physical quality, more diminutive size, and speedier trading. Light-releasing diodes are used as a piece of employments as various as flight lighting, auto headlamps, advancing, general lighting, development signals, camera flashes, and lit scenery. Beginning at 2017, LED lights home room lighting are as terrible or more affordable than decreased glaring light wellsprings of equivalent output. They are in like manner basically greater imperativeness successful and, evidently, have a significant measure of regular concerns associated with their disposal.

Not at all like a laser, the shade of light transmitted from a LED is neither conscious nor monochromatic, yet the range is limited with respect to human vision, and for most purposes the light from a direct diode part can be seen as essentially monochromatic.

Advantages

- Viability: LEDs release a bigger number of lumens per watt than brilliant light bulbs. The capability of LED lighting mechanical assemblies is not affected by shape and size, not in any manner like glaring lights or tubes.
- Shading: LEDs can transmit light of a normal shading without using any shading channels as customary lighting methods require. This is more capable and can cut down starting costs.

- Measure: LEDs can be pretty much nothing (smaller than 2 mm^2) and are easily added to printed circuit sheets.
- Warmup time: LEDs enlighten quickly. A common red pointer LED achieves full brightness in under a microsecond. LEDs used as a piece of specific devices can have extensively snappier response times.
- Cycling: LEDs are ideal for uses subject to visit on-off cycling, not in any manner like brilliant and glaring lights that bomb snappier when cycled routinely, or high-compel discharge lights (HID lights) that require a long time before restarting.
- Obscuring: LEDs can without a lot of an extend be lessened either by beat width adjust or cutting down the forward current. This pulse width change is the reason LED lights, particularly headlights on cars, when seen on camera or by a couple of individuals, appear, from every angle, to be bursting or blazing. This is a sort of stroboscopic affect.
- Cool light: as opposed to most light sources, LEDs exude beside no glow as IR that can make hurt sensitive articles or surfaces. Misused energy is scattered as warmth through the base of the LED.
- Direct dissatisfaction: LEDs for the most part bomb by lessening after some time, rather than the surprising disillusionment of splendid bulbs.
- Lifetime: LEDs can have a reasonably long profitable life. One report gages 35,000 to 50,000 hours of significant life, however time to complete dissatisfaction may be longer. Fluorescent tubes regularly are assessed at around 10,000 to 15,000 hours, depending most of the way on the conditions of usage, and splendid lights at 1,000 to 2,000 hours. A couple of DOE shows have exhibited that diminished upkeep costs from this extended lifetime, rather than energy hold reserves, is the basic factor in choosing the payback time allotment for a LED product.
- Shock resistance: LEDs, being solid state parts, are difficult to hurt with outside paralyze, not in any way like fluorescent and shining handles, which are sensitive.

- Focus: The solid heap of the LED can be expected to focus its light. Brilliant and fluorescent sources every now and again require an external reflector to accumulate light and direct it usably. For greater LED wraps indicate inside reflection (TIR) central focuses are routinely used to a comparable effect. Regardless, when considerable measures of light are required many light sources are by and large passed on, which are difficult to focus or collimate towards a comparative target.

Disadvantages

- Beginning worth: LEDs are starting at now to some degree all the more expensive (cost per lumen) on a fundamental capital cost commence, than other lighting progresses. As of March 2014, no short of what one creator cases to have come to $1 per kilo lumen. The additional cost for the most part begins from the modestly low lumen yield and the drive equipment and power supplies required.
- Temperature dependence: LED execution, all things considered, depends upon the encompassing temperature of the working condition – or warm organization properties. Overdriving a LED in high encompassing temperatures may achieve overheating the LED package, over the long haul provoking contraption frustration. An adequate warmth sink is relied upon to keep up long life. This is especially basic in auto, therapeutic, and military uses where devices must work over a broad assortment of temperatures, which require low disillusionment rates. Toshiba has made LEDs with a working temperature extent of −40 to 100 °C, which suits the LEDs for both indoors and outdoors use in applications, for instance, lights, rooftop lighting, street lights, and floodlights.
- Voltage affectability: LEDs must be given a voltage over their edge voltage and a current underneath their rating. Current and lifetime change altogether with a little change in associated voltage. They thusly require a current-coordinated supply (regularly just a game plan resistor for marker LEDs).

- Shading understanding: Most cool-white LEDs have spectra that difference basically from a dull body radiator like the sun or a splendid light. The spike at 460 nm and dive at 500 nm can influence the shade of things to be seen differently under cool-white LED lighting up than sunlight or shining sources, due to metamerism, red surfaces being rendered particularly inadequately by ordinary phosphor-based cool-white LEDs.
- Domain light source: Single LEDs don't vague a point wellspring of light giving a round light flow, however rather a lambertian movement. So LEDs are difficult to apply to uses requiring a roundabout light field; regardless, uncommon fields of light can be controlled by the usage of different optics or "central focuses". LEDs can't give uniqueness underneath two or three degrees. On the other hand, lasers can create shafts with divergences of 0.2 degrees or less.
- Electrical furthest point: Unlike splendid lights, which illuminate paying little regard to the electrical limit, LEDs simply light with review electrical limit. To normally arrange source furthest point to LED contraptions, rectifiers can be used.
- Blue peril: There is a stress that blue LEDs and cool-white LEDs are by and by fit for outperforming safe purposes of control of the assumed blue-light hazard as described in eye prosperity points of interest, for instance, ANSI/IESNA RP-27.1– 05: Recommended Practice for Photo biological Safety for Lamp and Lamp Systems.
- Light pollution: Because white LEDs, especially those with high shading temperature, exude significantly more short wavelength light than conventional outdoors light sources, for instance, high-weight sodium vapor lights, the extended blue and green affectability of scotopic vision infers that white LEDs used as a piece of outside lighting cause liberally more sky glow. The American Medical Association forewarned on the usage of high blue substance white LEDs in street lighting, due to their higher impact on human prosperity and condition, stood out from low blue substance light sources (e.g. High-Pressure Sodium, PC brilliant LEDs, and low CCT LEDs).

- Capability hang: The viability of LEDs lessens as the electric current augmentations. Warming in like manner increases with higher streams, which deals LED lifetime. These effects put sober minded cutoff focuses on the current through a LED in high power applications.
- Impact on frightening little creatures: LEDs are considerably more engaging bugs than sodium-vapor lights, to such a degree, to the point that there has been hypothetical stress over the probability of aggravation to sustenance webs.
- Use in winter conditions: Since they don't emanate much warmth interestingly with splendid lights, LED lights used for development control can have snow obfuscating them, inciting accidents.

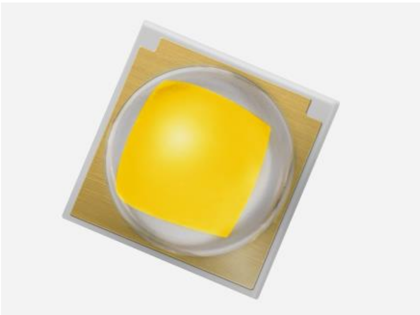

Fig 5. LED

CHAPTER 2

MACHINING DESIGN

Bottle

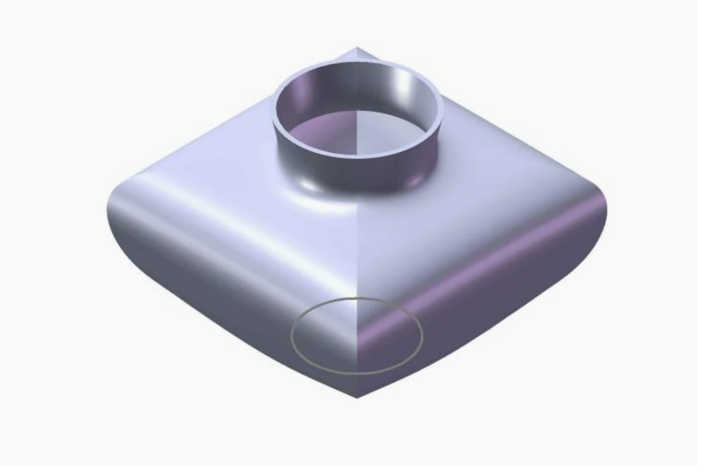

Fig 6. Lamp bottle

This lamp has a small battery and an electronic circuit. These things should be hidden from users' eye to give the lamp more attractive look. These non-eye friendly things were stored inside a small bottle.

Bottle lid

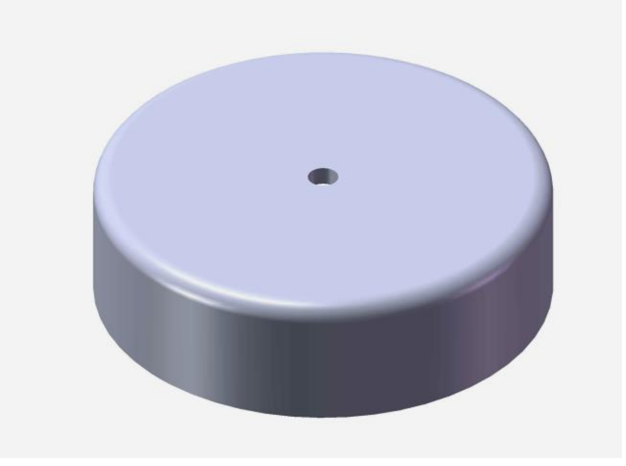

Fig 7. Bottle lid

Lamps content was enclosed with a small lid.

Heat sink

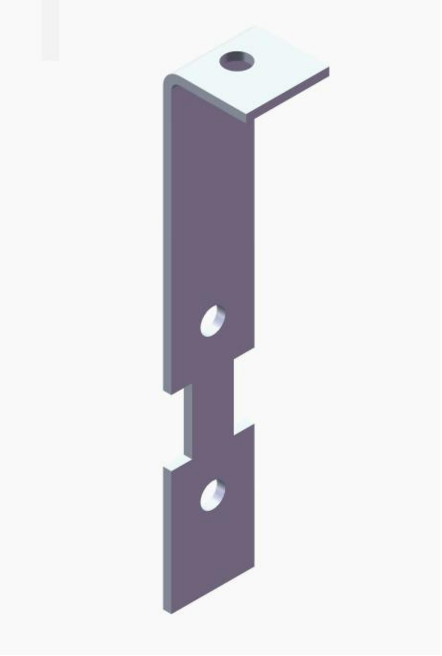

Fig 8. Heat conductor

Normally LED generates a large heat. This heat should be transferred to outer surrounding to protect the LED. This small heat sink and LED holder was designed to extend the lamp life.

LED Shield

Fig 9. LED Shield

LED should be properly tighten to the heat sink. This small metal shield covers the LED and tight heating components to heat sink.

PVC pipe to hold the LED

Fig 10. PVC Pipe

This small PVC pipe was used to cover the LED and heat conductor. It was designed to give a more attractive appearance.

PVC pipe cover at the top

Fig 11. PVC Pipe cover top

LED and heat sink was covered with a PVC shell. This small PVC part was used to cover the pipe at the top. PVC was used in this lamp to reduce production cost.

PVC pipe cover at the bottom

Fig 12. PVC Pipe cover bottom

PVC case was used to cover LED and heat sink. This PVC part was used to cover the pipe at the bottom.

Battery holder

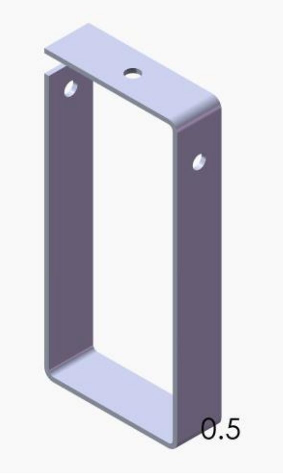

Fig 13. Battery holder

Small scale lead-acid battery was used to store energy. When lamp is moved this battery may produce vibration. This small metal piece was used to hold the battery firmly.

Lamp assembly drawing

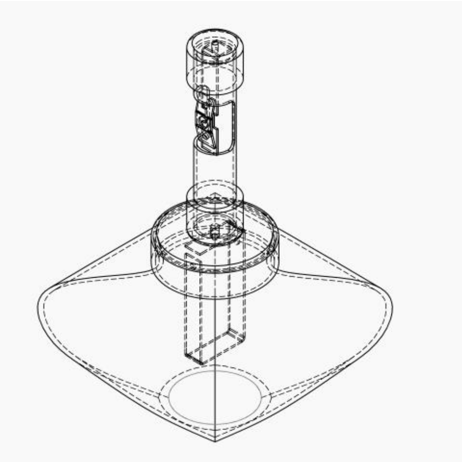

Fig 14. Lamp assembly

Huge effort was taken to build the lamp compactly. This assembly drawing shows the internal arrangement of components.

Exploded assembly drawing

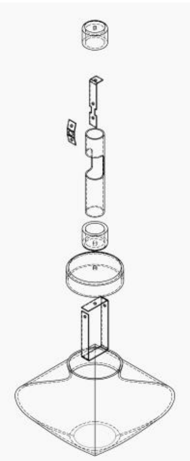

Fig 15. Lamp exploded view

When the lamp is assembled we should have an idea of arranging components. This exploded view helps manufactures to build it.

CHAPTER 3

ELECTRONIC DESIGN

1. Charger design

There are two main types of battery chargers available. They are,

1. Constant voltage chargers
2. Constant current chargers

There are various battery types available in the market. Lead acid batteries are used in automobiles & Electricity generators. This battery type is cheapest & commonly available in the general market. Ni-Cd & Ni-Mh batteries are used in consumer devices, calculators. This battery type has a large energy density & cost is relatively large. Li-Ion batteries are common in PDAs' & Mobile phones. This battery type provides largest energy density in a little big cost.

A small lead acid battery was chosen in this project to store energy. Lead can be recycled so that this lamp will be more environmental friendly. This battery is commonly available & cost is smaller. Lead acid batteries are normally charged with constant voltage chargers. A constant voltage is applied across lead-acid batteries in this charge mechanism. Constant charging voltage is defined in battery data sheet.

2. Battery

Lead-acid battery can be mathematically modeled with below equation.

I. Charging & discharging

Battery discharge function. ($i_{Lofr} > 0$)

$$f_{dc}(ExC, i_{Lofr}, i, Exp) = E_o - N.\frac{C}{C - ExC}.i_{Lofr} - a_i$$

$$a_i = N.\frac{C}{C - ExC}.ExC + L^{-1}(\frac{Exp(s)}{Cel(s)}.0)$$

Battery charge function ($i_{Lofr} < 0$)

$$f_{ch}(ExC, i_{Lofr}, i, Exp) = E_o - N.\frac{C}{ExC + 0.1.C}.i_{Lofr} - b_i$$

$$b_i = N.\frac{C}{C - ExC}.ExC + L^{-1}(\frac{Exp(s)}{Cel(s)}.\frac{1}{S})$$

E_o = Constant voltage (V)

Exp(s) = Exponential zone dynamics (V)

Cel(s) = Represents the battery mode.

Cel(s) = 0 during battery discharge, Cel(s) = 1 during battery charging.

N = Polarization constant (Ah-1) or Polarization resistance (Ohms)

i_{Lofr} = Low frequency current dynamics (A)

i = Battery current (A)

ExC = Extracted capacity (Ah)

C = Maximum battery capacity (Ah)

II. State of charge (SOC) calculation.

There are various methods to determine battery state of charge (SOC). They are measurement of specific gravity, terminal voltage and methods based on Ampere-hour (Ah) balancing. Specific gravity, Terminal voltage methods need a stabilization period to measure SOC. Most of places battery SOC is measure according to Ah balancing method because it's convenient.

Current flow in & out of battery is used to measure battery SOC in Ah balancing method. This will give accurate results, in shorter charging time periods such as electric vehicles. When longer time periods, and incomplete charging is considered this equation produce some errors due to accumulation of errors.

$$SOC_{T+1} = SOC_T + \frac{\sum_T \left(I_{bat}(T) - I_{gas}\right)}{C_{10}} * \Delta T \quad (1)$$

ΔT = Time interval between calculations

SOC_T = SOC at start time

$\overset{->}{I}_{bat}$ = Battery current (sign may be + or – based on the flow of current)

SOC_{T+1} = SOC after first calculation

I_{gas} is defined for Sonnenschein SB 12/60 Dryfit battery (A different battery was used in project. This information was added for people who need extra knowledge.) by,

$$I_{gas} = \frac{C_{10}}{100\,Ah} * I_{go} * p_i \qquad (2)$$

$$p_i = e^{\left[C_v\left(\frac{V_{bat}}{cell} - 2.23V\right) + C_t\left(T_{bat} - 20^0 C\right)\right]} \qquad (3)$$

I_{go} = Normalized gassing current

T_{bat} = Battery temperature

C_v = Voltage coefficient

C_t = Temperature coefficient

100 Ah is the normal battery capacity

C_{10} = Battery capacity at normal 10 h discharge rate

$V_{bat}/cell$ = Battery voltage per cell

3. Simulation

Constant voltage battery charger was simulated with battery model in certain voltages to see its' performance.

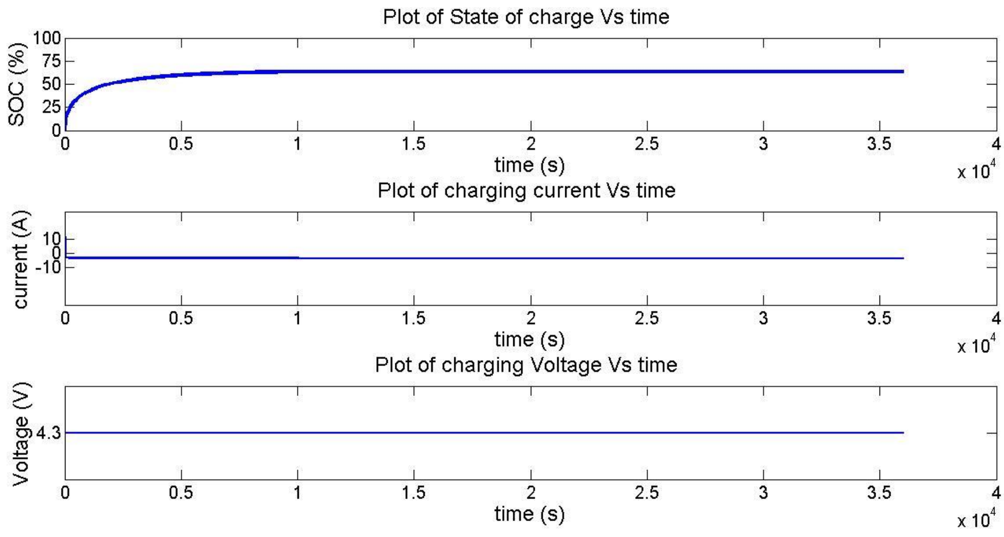

Fig 16. Battery charger 4.3V constant voltage operation

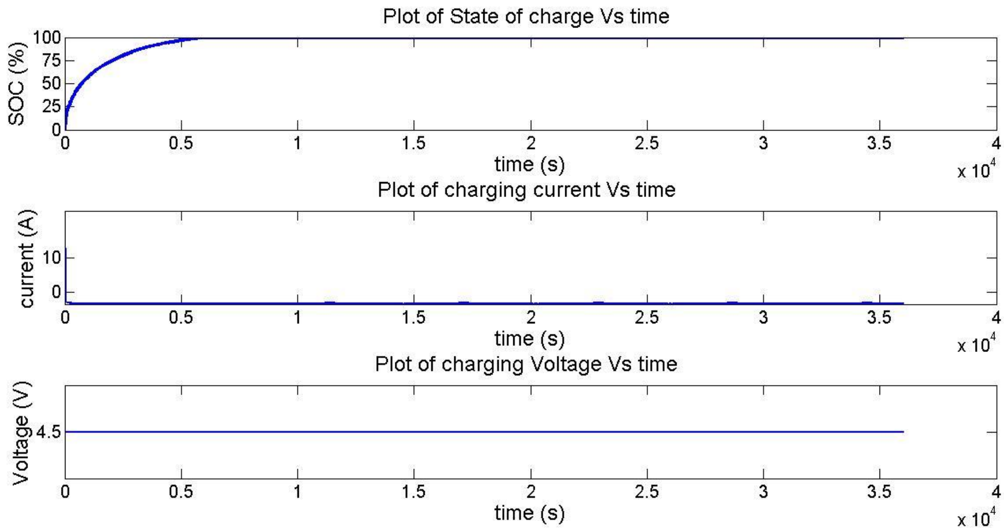

Fig 17. Battery charger 4.5V constant voltage operation

Constant voltage chargers are used to charge lead-acid batteries. Various voltages were applied to above models and simulated charging functionality with matlab. State of charge (SOC) is the charge percentage of the battery. A 4V battery was tested 10hrs in this simulation. When relatively small voltage is applied (4.3V) across battery it is difficult to get SOC to 100% according to simulations. Then a little large voltage (4.5V) is applied across battery it reaches its' full capacity (SOC = 100%) in a short duration according to simulations. If the battery kept in this state it reaches to its' capacity in a short time and overcharges. This effect for the life time of the battery. Therefore when a proper constant voltage is applied through battery it can be fully charged (SOC = 100%) in a reasonable duration. Battery was simulated in different voltages and its' charging behavior was observed. Matlab battery simulation self-generated reports were attached in appendix 1.

4. Charger circuit

Our target was to build a lamp in minimum cost. Therefore LM 317 T integrated circuit was chosen to charge our battery. It is a small scale voltage regulator IC. It can be configured to provide small constant voltages. A large circuit was miniaturized in this integrated circuit therefore a compact charger can be built with this. LM 317 IC can be obtain from common market easily so that people will be able to build lamps and do necessary maintenance activities of them. Configuring this IC to provide a constant voltage is not a tedious task.

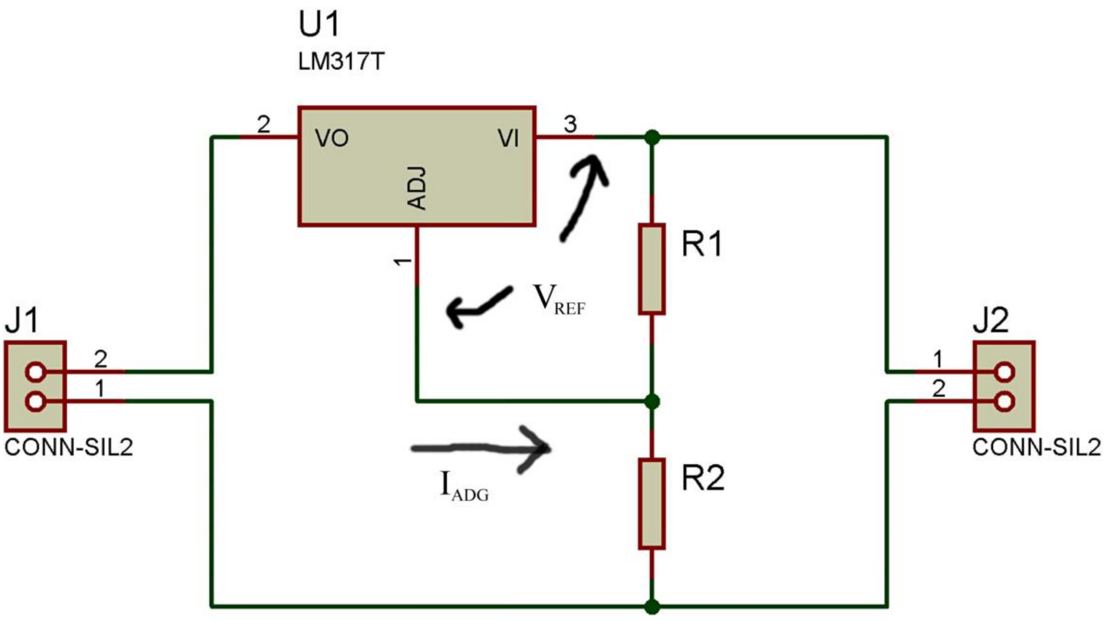

Fig 18. Simplified charger

Output voltage of LM 317 can be set with equation below.

$$V_o = V_{REF}\left(1+\frac{R_2}{R_1}\right)+I_{ADJ} * R_2$$

$V_O =$ Output Voltage

$V_{REF} =$ Reference Voltage (normally 1.25V)

$R_1 =$ Value of resistor R_1 in Ohms

$R_2 =$ Value of resistor R_2 in Ohms

$I_{ADG} =$ Current flow through pin 1 of IC (look at figure A1)

I_{ADG} For LM 317 integrated circuit is a relatively very small value (100 mA max). Therefore term $I_{ADG} * R_2$ can be neglected. Above equation can be minimized to obtain a simple formula as below.

$$V_o = V_{REF}\left(1 + \frac{R_2}{R_1}\right)$$

Values for above variables can be assigned and suitable resistor values (R_2)can be calculated. R_1 is normally selected as 240 Ω (assumed value). LM 317 can be configured to charge lead acid batteries in less effort and low cost.

LM 317 integrated circuit was configured to charge batteries as below. Variable resistor RV1 can be adjusted to set proper charging voltage. Charging voltage can be set according to simulation section results and battery datasheet. Output voltage of constant voltage charger should be in a suitable value to charge the battery in allowable time period. This simple circuit was used in our lamp to minimize the cost.

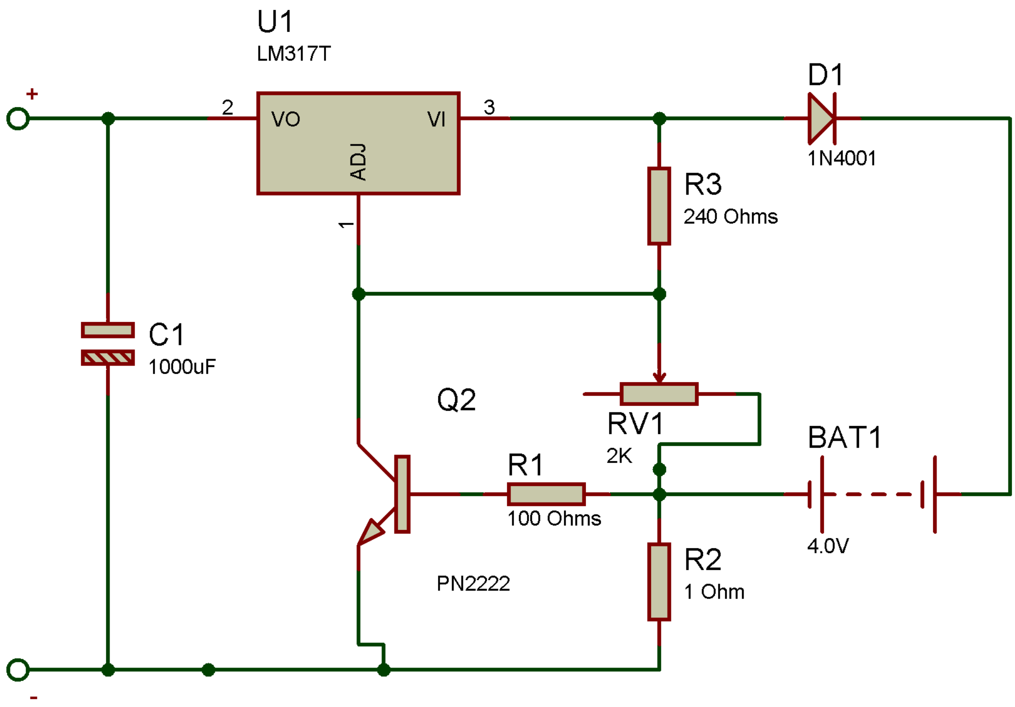

Fig 19. Charger circuit

5. Electrical Design of the Lamp

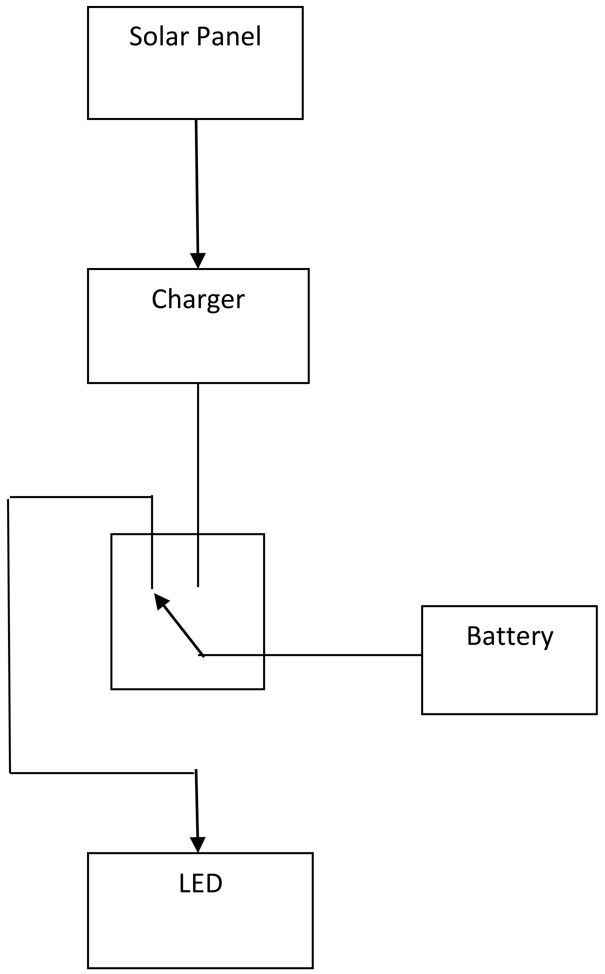

Fig 20. Block diagram of lamp

Day and night interchange can be used to control charge time of the battery. When a battery overcharges it get damage in a short period. If battery is kept discharge longer period it's performance decreases. This is called memory effect. Therefore when a battery is charged & used in regular basis battery life time can be maintained. When proper charge voltage is applied by charger battery can be charged in reasonable time period. This stored battery energy is used in night to illuminate rooms.

6. Lamp design

Fig. 21. Rendered lamp image

Lamp components were assembled and assembly design was obtained. It was rendered with CAD software and it’s appearance was observed.

CHAPTER 4

PROJECTS' ACHIEVEMENTS

A reliable supplier network was built to support lamp manufacturers. All the components required to manufacture lamp were brought to local stores. Certain parts required to manufacture lamps were rarely available in common market. Discussions were carried out with foreign suppliers & able to arrange proper supplier chain. All most all components can now be obtained from local stores.

We choose solar world as our solar panel supplier. Solar panels are not manufactured in Sri Lanka. We had to use a single 5w, off grid solar panel per lamp. There fore discussions were carried out with a foreign company and able to get a foreign contribution. Solar world is based on Germany and one of the largest manufacturers of solar modules. They made necessory arrangements for us to obtain solar panels from local market through their dealer. Now our manufacturers can obtain solar panels reliably from their local store.

Initially PCB for the lamp was manufactured manually. The copper paths were not properly made in manual method. Then circuit was designed with Proteus software & copper track layout was produced. It was redesigned to minimize PCB surface area. This preserved the space & reduced production cost. Then Gerber files were made & send to a PCB manufacturer for PCBs. Specifications were made and PCB order was placed online. After 10 days passed store informed me PCBs are ready.

Certain tools were required to fabricate lamps. Some tools are manual and other are power tools. This lamp was manufactured with localy available tools. This was designed to manufacture with simple machines. All the tools can be purchased from local dealers. Required electronic components can be purchased from local stores.

Required supplier network was build and project is ready for deliver to manufactures.

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Appendix –A

Simulation

Simulation for 4V nominal voltage 300 mAH capacity Lead-Acid battery (4.2V charge)

```
cur_4v = Curr_selct_4;
volt_4v = Volt_Select_4;
soc_4v = SOC_4;
cur_1_4v = current_4;
volt_1_4v = Voltage_4;

figure
subplot(3,1,1)
p1=plot (soc_4v.time, soc_4v.signals.values)
set(gca,'YTick',0:25:100,'FontSize',15)
set(gca,'YTickLabel',{'0','25','50','75','100'},'FontSize',15)
xlabel('time (s)','FontSize',18)
ylabel('SOC (%)','FontSize',18)
title('Plot of State of charge Vs time ','FontSize',18)
% Change the line color to red and
% set the line width to 2 points
set(p1,'Color','blue','LineWidth',3)

subplot(3,1,2)
p2=plot(cur_4v.time,cur_4v.signals.values)
set(gca,'YTick',-10:15:20,'FontSize',10)
set(gca,'YTickLabel',{'-10','0','10','20'},'FontSize',15)
xlabel('time (s)','FontSize',18)
ylabel('current (A)','FontSize',18)
title('Plot of charging current Vs time ','FontSize',18)
% Change the line color to red and
% set the line width to 2 points
set(p2,'Color','blue','LineWidth',2)

subplot(3,1,3)
p3=plot(volt_1_4v.time,volt_1_4v.signals.values)
set(gca,'YTick',3.5:0.1:5.5,'FontSize',15)
set(gca,'YTickLabel',{'3.5','3.6','3.7','3.8','3.9','4','4.1','4.2','4.3','4.4','4.5
','4.6','4.7','4.8','4.9','5','5.1','5.2','5.3','5.4','5.5'},'FontSize',15)
xlabel('time (s)','FontSize',18)
ylabel('Voltage (V)','FontSize',18)
title('Plot of charging Voltage Vs time ','FontSize',18)
% Change the line color to red and
% set the line width to 2 points
set(p3,'Color','blue','LineWidth',2)
```

```
p1 =
```

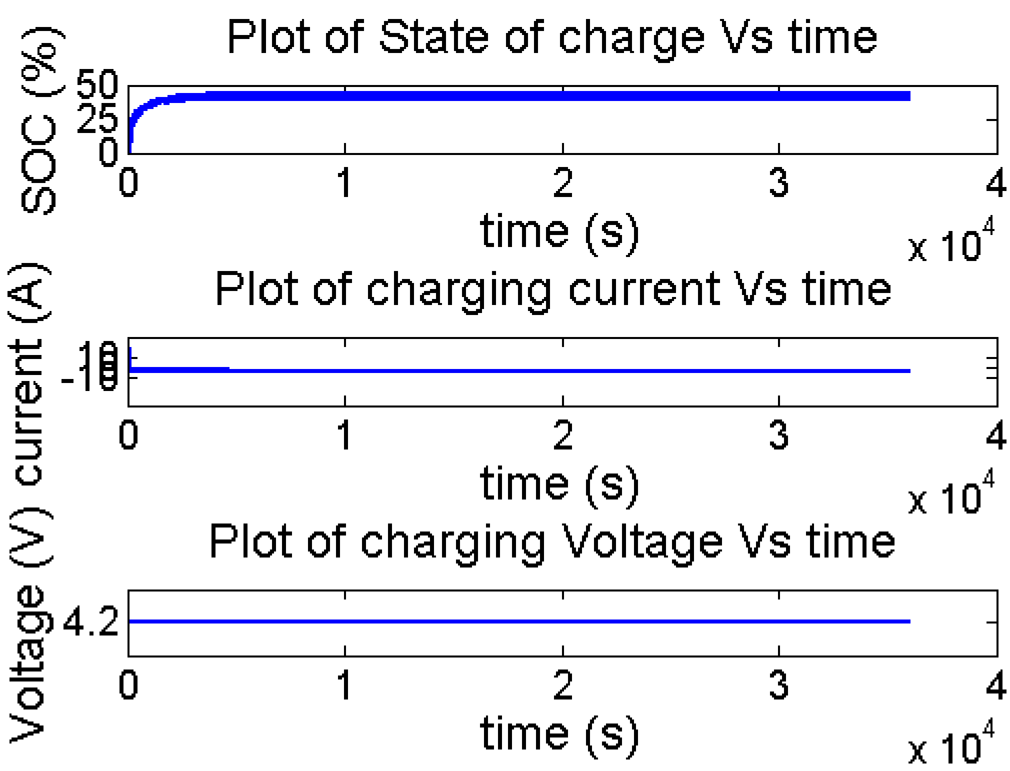
```
    1.4401e+04


p2 =

    1.4406e+04


p3 =

    1.4411e+04
```



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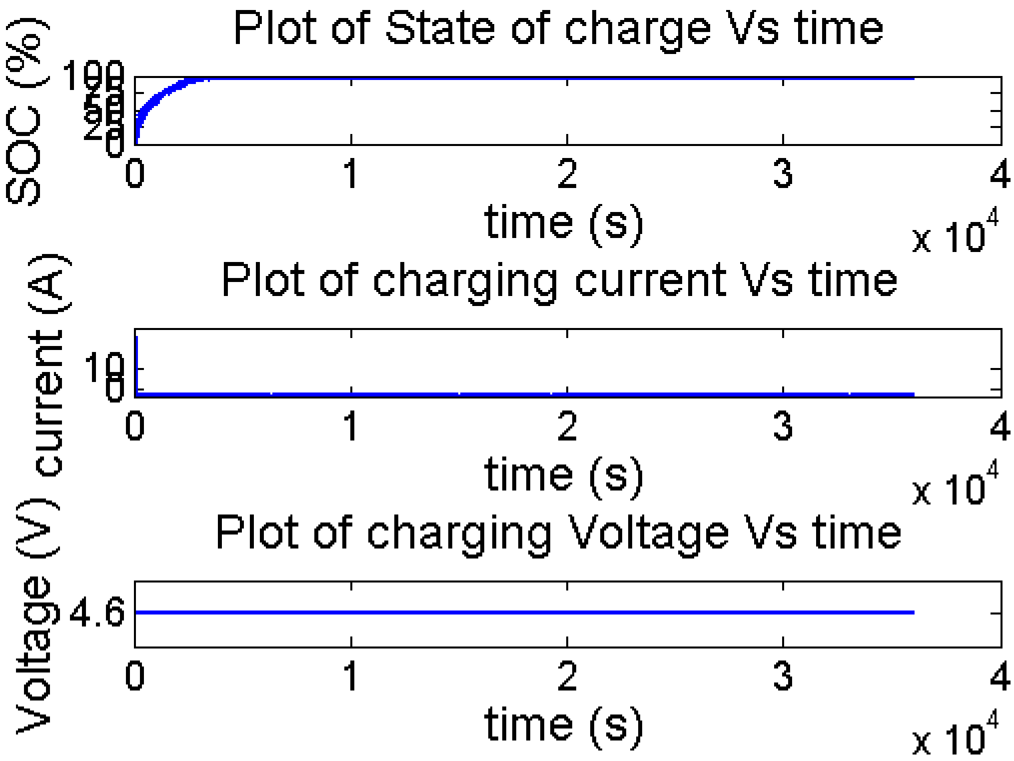
Simulation for 4V nominal voltage 350mAH capacity Lead-Acid battery (4.6V charge)

```
cur_4v = Curr_selct_4;
volt_4v = Volt_Select_4;
soc_4v = SOC_4;
cur_1_4v = current_4;
volt_1_4v = Voltage_4;

figure
subplot(3,1,1)
p1=plot (soc_4v.time, soc_4v.signals.values)
set(gca,'YTick',0:25:100,'FontSize',15)
set(gca,'YTickLabel',{'0','25','50','75','100'},'FontSize',15)
xlabel('time (s)','FontSize',18)
ylabel('SOC (%)','FontSize',18)
title('Plot of State of charge Vs time ','FontSize',18)
% Change the line color to red and
% set the line width to 2 points
set(p1,'Color','blue','LineWidth',3)

subplot(3,1,2)
p2=plot(cur_4v.time,cur_4v.signals.values)
set(gca,'YTick',-10:15:20,'FontSize',10)
set(gca,'YTickLabel',{'-10','0','10','20'},'FontSize',15)
xlabel('time (s)','FontSize',18)
ylabel('current (A)','FontSize',18)
title('Plot of charging current Vs time ','FontSize',18)
% Change the line color to red and
% set the line width to 2 points
set(p2,'Color','blue','LineWidth',2)

subplot(3,1,3)
p3=plot(volt_1_4v.time,volt_1_4v.signals.values)
set(gca,'YTick',3.5:0.1:5.5,'FontSize',15)
set(gca,'YTickLabel',{'3.5','3.6','3.7','3.8','3.9','4','4.1','4.2','4.3','4.4','4.5
','4.6','4.7','4.8','4.9','5','5.1','5.2','5.3','5.4','5.5'},'FontSize',15)
xlabel('time (s)','FontSize',18)
ylabel('Voltage (V)','FontSize',18)
title('Plot of charging Voltage Vs time ','FontSize',18)
% Change the line color to red and
% set the line width to 2 points
set(p3,'Color','blue','LineWidth',2)
```

```
p1 =

   5.3640e+03


p2 =
```

```
    5.3690e+03


p3 =

    5.3740e+03
```



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Appendix – B

Gerber Files and PCB

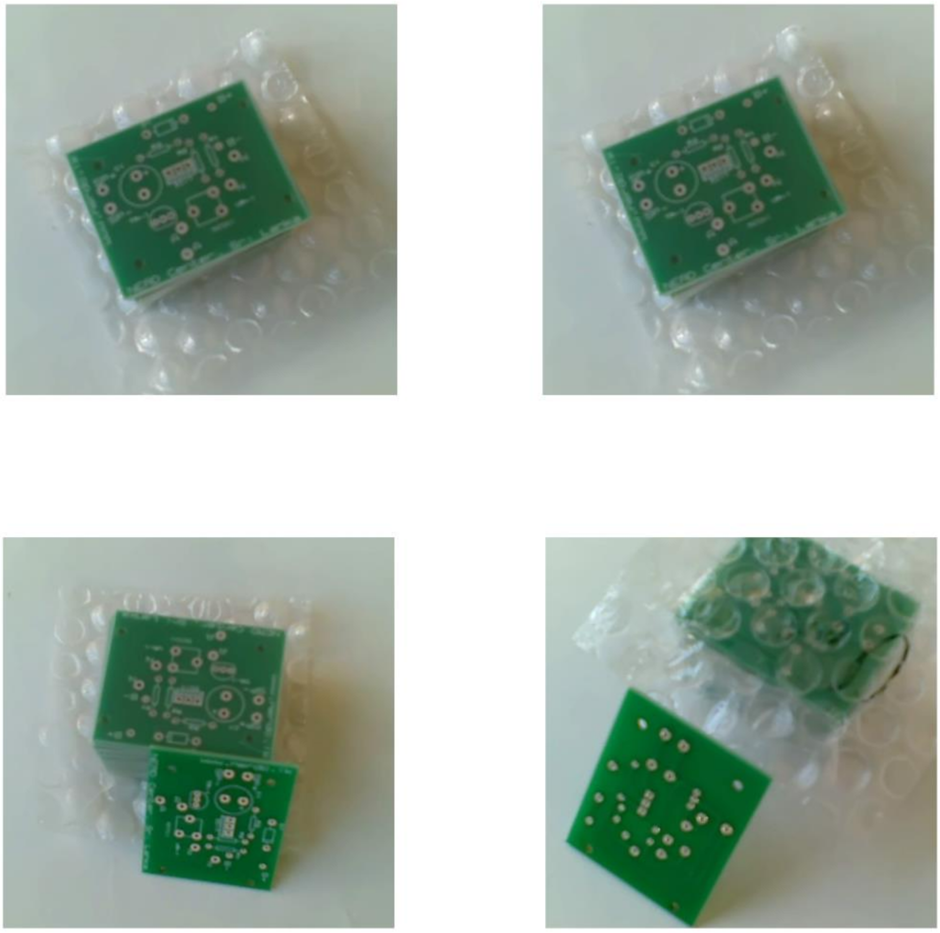

Fig. 22. PCBs