INVESTIGATIONS ON INTRODUCING OF LED BASED LIGHTING SYSTEM IN DELHI METRO

A DISSERTATION SUBMITTED TOWARDS THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY

IN

POWER ELECTRONICS SYSTEM

(2013-2016)

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I, **Sanjeev Kumar**, Student of **M.Tech**. **(PES)**, 2K13/PES/506, hereby declare that the thesis titled "**INVESTIGATIONS ON INTRODUCING OF LED BASED LIGHTING SYSTEM IN DELHI METRO**", has been done under the guidance of Sh. **Amritesh Kumar,** Faculty of Electrical Engineering Department, Delhi Technological University (Formerly Delhi College of Engineering**)** in the partial fulfillment of the requirements for the award of the degree of Master of Technology in Power Electronic System, has not been submitted elsewhere for the award of any Degree.

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ACKNOWLEDGEMENT

I would like to express my sincere thanks to my project guide SH. AMRITESH KUMAR, for all his supports provided to me during the course of the project. Without him, I would have never been able to take this project to completion. His continued cooperation, patience never-ending encouragement, meticulous guidance, motivation and uninhibited support at various stages helped me in preparation of this research study.

I would also like to thank Prof. Vishal Verma, Dean of PG courses & Controller of Examinations of DTU for his cooperation, support and problem solving attitude.

I am also very thankful to Prof. Narendra Kumar for his encouragements and supports provided to me all the time.

I am also thankful to all members of Electrical Engineering department for their continuous help.

I would also like to acknowledge the guiding role of my seniors and colleagues from my present organization Delhi Metro Rail Corporation Limited, in providing me with the opportunity to gain insight into the existing Lighting System of Metro Station along with its techno-commercial details.

Lastly, my thanks to my family and friends for their always encouraging supports & motivations.

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ABSTRACT

Illumination is an important factor for mental and physical well-being, mood elevation, safety and security of a passenger using the Metro system for his transportation need. There are many factors that need to be considered carefully while designing lighting for Metro Systems. They are Safety & Health, Appearance & comfort, Energy and Cost Effectiveness.

Lighting system in Metro Rail Systems is unlike other applications as there are various different type of application areas viz. Stations (Underground & Elevated), Passenger Areas, Non-Passenger Areas, Train Depots etc. Thus, it becomes imperative that Lighting Design is carried out carefully considering factors such as Safety & Health, Performance, Appearance & Comfort and Energy & Cost Effectiveness.

Metro System typically has various types of Application Areas. These areas can be broadly divided into two categories viz. Public & Non-Public Areas. Public Areas are Passenger areas such as Platform, Concourse, and Entrances/Exits etc. Lighting in these areas has to be designed keeping in mind the comfort of the passengers as well as energy saving.

DMRC has been keen to reduce its energy consumption. At equipment level, high efficient equipments & their accessories are selected but one of major concerns where energy consumption is significant and saving can be done is 'Lighting' At a typical underground station where about 19 Hrs of duration, Lighting system is 'ON' which if regulated, can able to save lots of energy.

LED lighting due to its spurious advantages of high efficiency, color rendering index, color temperature and longer life, Delhi Metro introduced the LED based lighting system. Hence, there comes need to review the lighting needs of DMRC and introduce some better alternatives.

Thus, introducing of LED based Lighting system is a techno-commercial solution in order to fulfill DMRC specific requirements with advantage of Energy Saving.

Keywords: DMRC, Metro, Energy Saving, LED Lighting.

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CHAPTER 1
Introduction

A considerable portion of electrical energy generated all over the world is converted in artificial lighting. Lighting in industrial and household applications consumes about 19% of the electrical energy produced worldwide. That is why any improvement of lighting systems efficiency conserves significant amount of energy. The energy efficiency of electric lighting has increased radically since the state-of-art technological development in the lighting loads from an incandescent light bulb to LED lamp.

In a Metro system, illumination is a very important factor for mental and physical well-being, mood elevation, safety and security of a passenger using the Metro system for his transportation need. There are many factors that need to be considered carefully while designing lighting for Metro Systems. They are Safety & Health, Appearance & comfort, Energy and Cost effectiveness.

Lighting system in Metro Rail Systems is unlike other applications as there are various different type of application areas viz. Stations (Underground & Elevated), Passenger Areas, Non-Passenger Areas, Train Depots etc. Thus it becomes imperative that Lighting Design is carried out carefully considering factors such as Safety & Health, Performance, Appearance & Comfort and Energy & Cost Effectiveness.

Metro System typically has various types of Application Areas. These areas can be broadly divided into two categories viz. Public & Non-Public Areas. Public Areas are Passenger areas such as Platform, Concourse, and Entrances/Exits etc. Lighting in these areas has to be designed keeping in mind the comfort of the passengers.

The burning hours of Lights in Public Areas is very high for underground stations, generally in the tune of 18 to 20 hours per day. Due to long burning hours and interface with the passengers it becomes imperative that Lights used in these areas should have long life and are energy efficient.

Non-Public areas are utility areas housing the plant rooms, equipment rooms & depots etc. Lighting in these areas have to be designed keeping in mind the activities carried out in the room. Certain areas like Station Control Room & Signaling & Telecom rooms have higher Lux level requirements compared to other equipment rooms.

Energy saving has been a prime concern now a days and every organization, government and even at an individual level are trying to reduce energy consumption. DMRC Ltd is an organization for public mode transport as Mass Rapid Transit System & Consumes huge power in the range 644 MU which comprises of 419 MU for Traction power and 211 MU for auxiliary system (Non – traction power) in a year in which Lighting contribution is of about 7.5%, a significant portion.

Auxiliary system comprises of all system being provided at a particular station for all such facilities and equipments. DMRC has been keen to reduce its energy consumption at equipment level as well as at operation level.

In earlier DMRC phases, DMRC used T-8 (36w) fittings while in current phase (i.e Phase-III), T-5 were introduced but in the meantime 'LED' based lighting system comes and DMRC has also taken initiative to have LED based lighting system at its stations (through not in original scope of work). So here come the need for 'LED based lighting system'.

LED being a new field, there has been many concerns in regard to its reliability, utility, after – sales service support and many myths- reality but lastly with all discussions, problems, DMRC goes with LED based lighting system.

This project paper presents a detailed investigations of how the LED based lighting system has been introduced with what advantages experienced and what are the constraints/ problems faced during uses of its introduction.

1.1 Light-Emitting Diode (LED)

The light-emitting diode is one of today's most energy-efficient and rapidly-developing lighting technologies convert electrical energy into light energy. The “Light Emitting Diode” or LED is basically just a specialized type of diode as they have very similar electrical characteristics to a PN junction diode. This means that an LED will pass current in its forward direction but block the flow of current in the reverse direction.

(a) Electrical And Optical Properties

Light emitting diodes are made from a very thin layer of fairly heavily doped semiconductor material and depending on the semiconductor material used and the amount of doping, when forward biased an LED will emit a coloured light at a particular spectral wavelength.

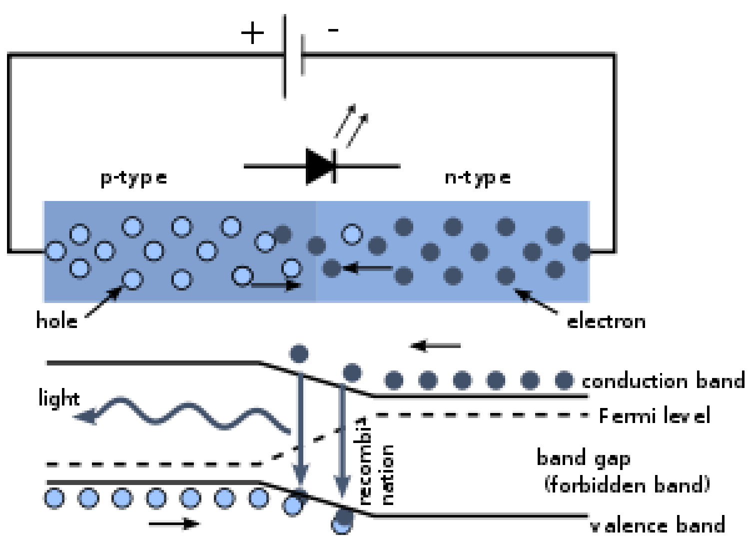


FIG.1.1: LED, Circuit (top) and Band Diagram (bottom)

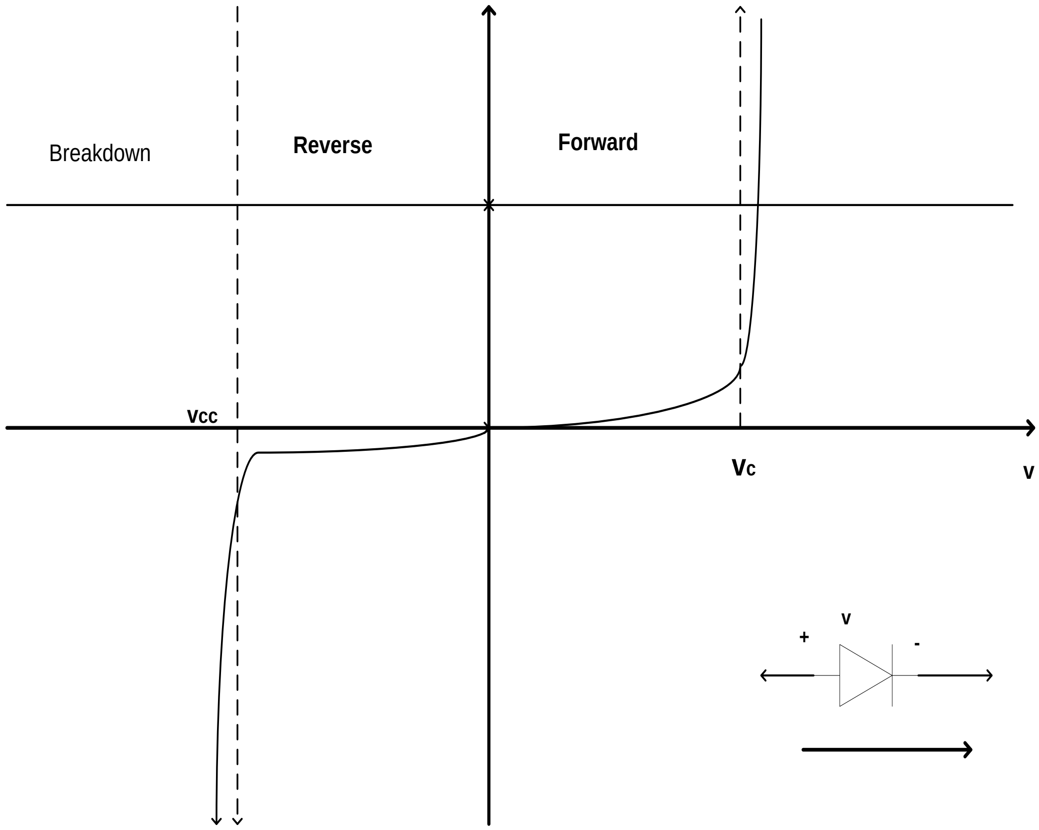


FIG.1.2:I-V diagram for a diode

Like conventional PN junction diodes, light emitting diodes are current-dependent devices with its forward voltage drop VF, depending on the semiconductor compound and on the forward biased LED current.

The LED consists of a chip of semiconducting material doped with impurities to create a p-n junction. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode, but not in the reverse direction. Charge-carriers—electrons and holes—flow into the junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level and releases energy in the form of a photon.

The wavelength of the light emitted, and thus its color, depends on the band gap energy of the materials forming the p-n junction.

(b) Advantages

Efficiency: LEDs emit more lumens per watt than incandescent light bulbs. The efficiency of LED lighting fixtures is not affected by shape and size unlike fluorescent light bulbs or tubes.

Color: LEDs can emit light of an intended color without using any color filters as traditional lighting methods need. This is more efficient and can lower initial costs.

Size: LEDs can be very small (smaller than 2 mm) and are easily attached to printed circuit boards.

Warmup time: LEDs light up very quickly. A typical red indicator LED will achieve full brightness in under a microsecond. LEDs used in communications devices can have even faster response times.

Cycling: LEDs are ideal for uses subject to frequent on-off cycling, unlike incandescent and fluorescent lamps that fail faster when cycled often, or high-intensity discharge lamps (HID lamps) that require a long time before restarting.

1.2 Photovoltaic System

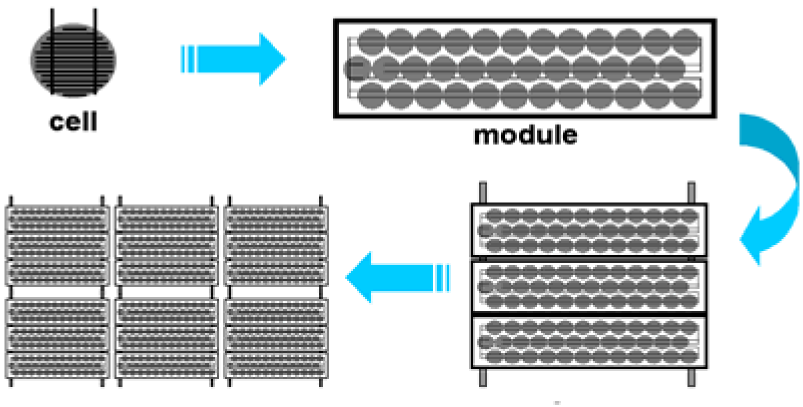
A photovoltaic system is a system which uses one or more solar panels to convert solar energy into electricity. It consists of multiple components, including the photovoltaic modules, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output.

(a) Photovoltaic technologies and photovoltaic cell

PV cells are basically semiconductor diodes. PV cells are made of semiconductor materials, such as silicon. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current - that is, electricity.

(b)Photovoltaic module

The power produced by a single PV cell is not enough for general purpose use. By connecting many single PV cell in series (for high voltage requirement) and in parallel(for high current requirement) can get us the desired power is chosen. The set of a series connection arrangement is known as a module. Generally commercial modules consist of 36 or 72 cells. The modules consist of transparent front side, encapsulated PV cell and back side. The front side material is usually made up of low-iron and tempered glass. The efficiency of a PV module is less than a PV cell. This is due to the fact that some radiation is reflected by the glass cover and frame shadowing etc.



arrays **panel**

- **Fig 1.3: Photovoltaic cells, modules, panels and arrays.**

(c) The Array of Photovoltaic

A photovoltaic array (PV system) is a interconnection of modules which in turn is made up of many PV cells in series or parallel. The power produced by a single module is seldom enough for commercial use, so modules are connected to form array to supply the load. The connection of the modules in an array is same as that of cells in a module. Modules can also be connected in series to get an increased voltage or in parallel to get an increased current. In urban uses, generally the arrays are mounted on a rooftop.

Most PV arrays use an inverter to convert the DC power into alternating current that can power the motors, loads, lights etc. The modules in a PV array are usually first connected in series to obtain the desired voltages; the individual modules are then connected in parallel to allow the system to produce more current

(d) The model and Working of Photovoltaic Cells

PV cell is based on the basic principle of photoelectric effect and it can be can be defined as a phenomenon in which an electron gets ejected from the conduction band as a consequence of the absorption of sunlight of a certain wavelength by the matter(metallic or non-metallic solids, liquids or gases).In a photovoltaic cell, The ray of light, assimilated to photons, passes through the top layer (N doped) of the photovoltaic cell. Then, electrons capture the photons' energy and help them to cross the potential barrier of the PN junction, which generates current. So there is a strong relation between the solar irradiance and the amplitude of the generated current.

(e) Characteristics of a PV cell

In a PV characteristic there are basically three important points viz. open circuit voltage, short circuit current and maximum power point. The maximum power that can be extracted from a PV cell are at the maximum power points. Usually manufacturers provide these parameters in their datasheets for a particular PV cell or module. By using these parameters we can build a simple model but for more information is required for designing an accurate model.

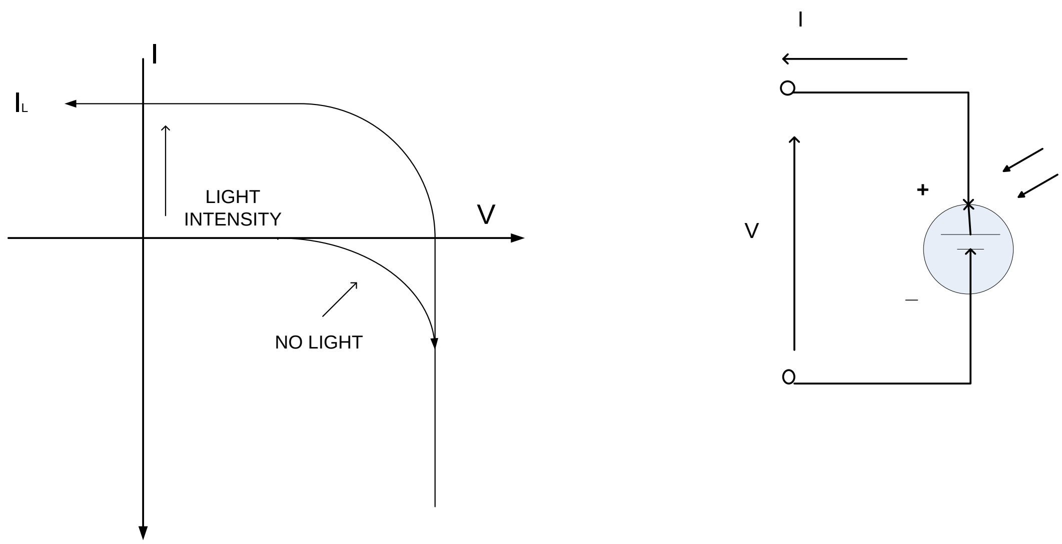


Fig 1.4: I-V Curve of PV Cell and Associated Electrical Diagram

In an ideal cell, the total current I is equal to the current Iℓ generated by the photoelectric effect minus the diode current ID, according to the equation:

$$I = I_L - I_D = I_L - I_0 \left(e^{qv/kT} - 1 \right)$$

where I_0 is the saturation current of the diode, q is the elementary charge 1.6x10-19 Coulombs, k is a constant of value 1.38x10-23J/K, T is the cell temperature in Kelvin, and V is the measured cell voltage.

Expanding the equation gives the simplified circuit model shown below and the following associated equation, where n is the diode ideality factor (typically between 1 and 2), and RS and RSH represents the series and shunt resistances.

$$I = I_L - I_0 \left(\exp^{q(V+IRs/n.k.T} - 1 \right) - V + I.Rs/R_{SH}$$

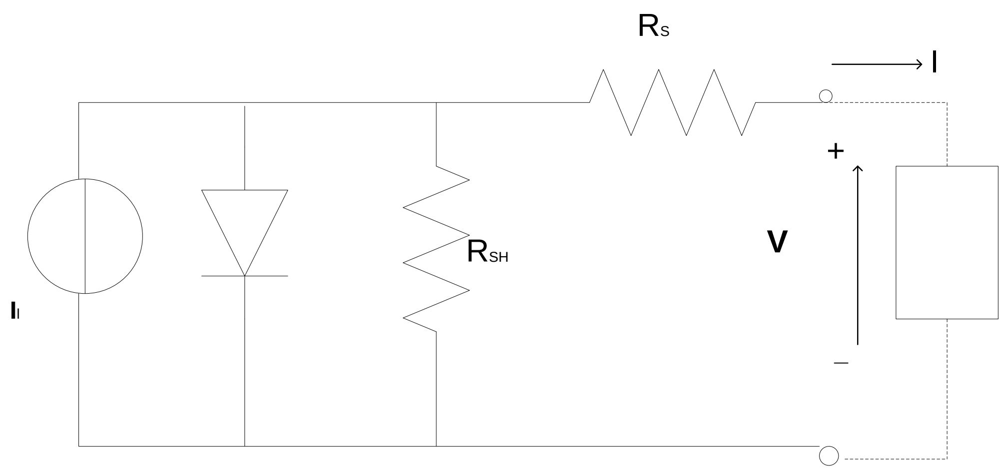


Fig 1.5: Simplified Equivalent Circuit Model for a Photovoltaic Cell

The I-V curve of an illuminated PV cell has the shape shown in Fig 1.6 as the voltage across the measuring load is swept from zero to V_{OC}, and many performance parameters for the cell can be determined from this data.

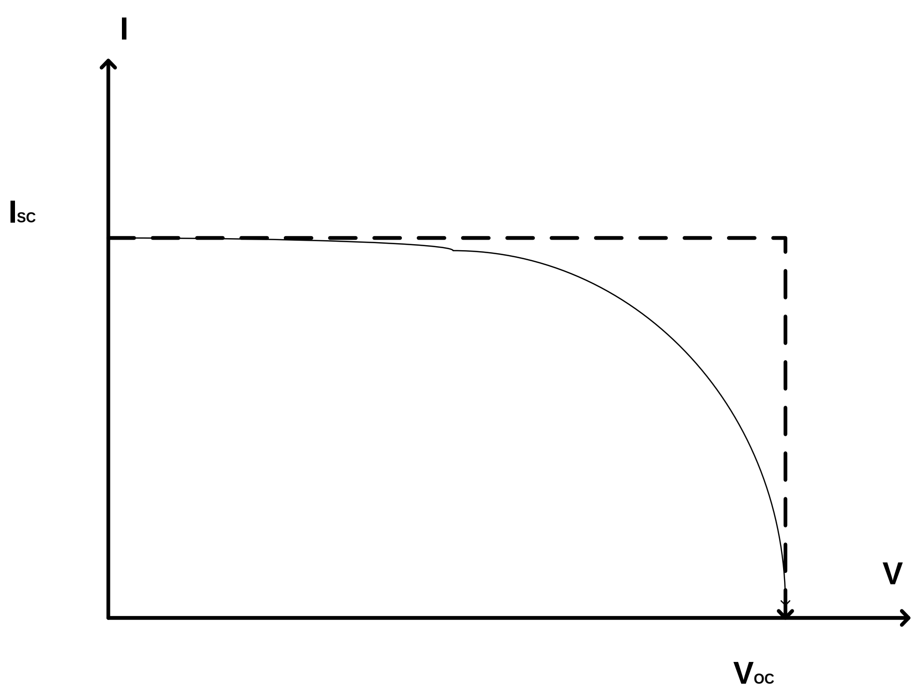


Fig1.6 - Illuminated I-V Sweep Curve

CHAPTER-2

LITERATURE SURVEY

For the study of LED based lighting applications and latest trend in its developments, various IEEE literatures and authors' papers have been studied. The survey enlightens the various improvements done / being done in this field of LED based lighting system in respect of its efficiency, reliability, quality, efficacy, colors etc. and this to be used in customized requirements of DMRC. These are discussed with various renowned LED lights manufacturers like Philips, Osram, Surya, Crompton, Steller etc and they were ask to develop light fixtures with these such specific requirements of DMRC . Few succeeded to a much extent but some are still in process of developing.

There are several journals have been published in previous years regarding to the use of DC-DC converters to improve the efficiency of LED based lighting system and technology and the important observations are mentioned below.

In the analog dimming methods, the LED current level of each string is regulated by adjusting the reference level of the individual current feedback loop. This method is simple and cost effective, but it can also cause color variation. To adjust the LED brightness without color variation over full dimming range, PWM dimming methods have been presented, in which the amplitude of the pulsating LED current is kept constant and the pulse width is regulated. Both linear and switching regulators can be used in either analog or PWM dimming methods. The efficiency of the LED driver with switching regulators is higher than that of the driver with linear regulators. Thus, the PWM dimming method with switching regulators is the trend for future LED driving systems because of its high efficiency and better illumination quality. The novel twin-bus based LED driver improves the efficiency.

In order to reduce low-frequency ripple in light emitting diode (LED) arrays that are supplied from the AC grid, a series resonant DC–DC converter connected to the output of the power factor correction (PFC) stage so that the low-frequency ripple transmitted from the PFC stage to the LEDs can be minimized. This achieves two goals: (i) reduction of the bulk capacitance used at the output of the PFC stage so that long-life film capacitors can be employed, and (ii) increasing the efficiency of the LED driver owing to the low switching losses of the resonant converter.

The conventional structure of the solar LED street lighting utilizes two converters. One is used for battery charging in day. The other is used to supply the LED street lighting from the battery in night. For cost saving, the two converters should be integrated. A DC-DC converter is presented for the solar LED street lighting. In the day, the converter is used for a charging circuit & in the night, the converter is used for a discharging circuit. The renewable energies include solar power, wind power, ocean power, hydrogen power. In the energy saving, the high performance lightings, including high intensity discharge (HID) and high brightness light emitting diode (LED) lamps, are developed rapidly. The charging circuit is a DC-DC step-down converter and the discharging is a DC-DC step-up converter.

High brightness LEDs (HBLEDs) are solid state devices, hence they can withstand impact and vibration which allows their utility in automotive and aircraft lightings, traffic lightings, railway signals, indoor and outdoor lightings etc. The advantages of LEDs over CFLs (Compact Fluorescent Lamps) are that they do not emit harmful ultraviolet rays, turn on instantly to full brightness, their life span is not shortened due to frequent use and also there is no requirement of high ignition voltage.

Improved power quality converters (IPQCs) are classified on the basis of topology and type of converter used. The topology-based classification is categorized on the basis of boost, buck, buck-boost, multilevel, unidirectional and bidirectional voltage, current, and power flow. The converter type can be step-up and step-down choppers, voltage source and current-source inverters, bridge structure, etc.

CHAPTER-3

THE SCOPE OF WORK

At a typical underground metro stations, there are two ASS (Auxiliary sub stations) at platform level and with such a redundant design that each substation for all its essential and emergency loads is nearly backup to the other substation in case of failure of one substation. (other back ups are also there with DG sets and UPS for emergency lighting and emergency systems). For lighting system, from ASS Level, power is fed from main panel to lighting panel and lighting panel to lighting distribution boards (LDBs) i.e lights are being fed from these LDBs. There are different LDBs feeding lights to different areas. At this location, the light fittings have been replaced with LED lights.

The LUX levels required for different areas are tabulated below:-

Application	**Average Designed luminance in Lux**
Passenger Area (Public Area)	
Circulating and Parking Area	30
Entrance/Exit/Stairs/Escalators/Customer Care/Ticketing	250
Concourse/Corridors/Passages/ Toilets	200
Platform	200
Platform Edges	250
Train way, walk-ways and walking surfaces	10
Lifts	150
Operation Area (Non-Public Area)	
Staff Working Area/Control Room/OCC	250
Tunnel	20
Equipment & Plant Rooms	200
Underground Track Area and cable galleries	10

Table 3.1: Lux Table

3.1 SYSTEM IMPROVEMENT

The introduction of LED based lighting system bring out following advantages for which techno-commercial analysis is as under:-

LIGHT FIXTURE DETAILS OF TYPICAL UG STATION						
	LED			CONVENTIONAL		
PUBLIC AREA	WATTAGE	No. OF FITTINGS	TOTAL WATTAGE (W)	WATTAGE	No. OF FITTINGS	TOTAL WATTAGE (W)
CONCOURSE	156.6	22	3445.2	275	25	6875
	15	174	2610	26	90	2340
	42	94	3948	64	125	8000
PLATFORM	40.8	133	5426.4	64	172	11008
	29	67	1943	64	48	3072
SUBWAY	40.8	237	9669.6	64	250	16000
STAIRCASE	40.8	48	1958.4	64	66	4224
	275	12	3300	275	12	3300
		787	**32301W**		**788**	**54819W**

Table 3.2: Light fixture details of a typical UG Station

Thus, from the above table, it is clear that there is a saving of about 22.5 KW of lighting load at a single station which is about 40% saving.

3.2 Light Power Density (LPD)

Total Public Area at Station	Total Connected Load Conventional Lighting (W)	Total Connected Load LED Lighting (W)	LPD (W/m2)with Conventional Lighting	LPD (W/m2) with LED Lighting	LPD requirement given in ECBC and Ashrae for transportation
5600 m2	54819 W	32301 W	9.78 W/m2	5.77W/m2	10.8 W/m2

Table 3.3 Light power density

Light Power Density (LPD) is Power used on lighting per unit floor area of space. Total public area at an underground station is approx. 5600 sqm. Thus, LPD in case of conventional lighting is 9.78 W/m2 and in case of LED lighting is 5.77 W/m2. Therefore, a reduction of almost 41% w.r.t. to conventional lighting. The requirement for LPD as per ECBC for transportation system is 10.8 W/m2. Thus, by implementation of LED lights at Stations we are able to achieve LPD that is **46% lower** than that prescribed in the standards.

Capital Investment and Annual Energy Consumption Charges Analysis (With SITC)								
Type	Load (KW)	Total KWH per day)	Total KWH per year	Saving per year (KWH)	Saving @ Rs. 7 per KWH (A)	Initial Capital investment	**Extra Initial cost with LED (B)**	**Return on Investment (ROI=B/A) Yrs**
Normal	55	1096	400,179			1,600,000		
				152,920 (Aprox 40%)	1,070,443		3,900,000	4 Year Aprox
LED	**34**	**677**	**274,258**			**5,500,000**		

Table 3.4: Capital Investment and Annual Energy Consumption

CHAPTER 4

MODELLING AND CONTROL

4.1 CONVERTERS

A switching power supply consists of two stages (i) the power stage and (ii) the control circuit. The power stage performs the basic conversion of power from the input voltage side to the output voltage side and incorporates various switches and the output filter.

There are three types of basic switching power supplies. They are the buck, boost, and buck-boost. These topologies are nonisolated, i.e., the input and output voltages share a common ground. There are, however, isolated derivations of these nonisolated topologies. The power supply topology defines how the switches, output inductor, and output capacitor are interconnected. Each topology has its own configuration & property. This includes the steady-state voltage conversion ratios, the nature of the input and output currents, and the character of the output voltage ripple. Another important property is the frequency response of the duty-cycle-to-output-voltage transfer function.

4.2 DC-DC CONVERTERS

DC-DC converters can be used as switching mode regulators to convert an unregulated dc voltage to a regulated dc output voltage. The regulation is normally achieved by PWM at a fixed frequency and the switching device is generally BJT, MOSFET or IGBT. The minimum oscillator frequency should be about 100 times longer than the transistor switching time to maximize efficiency. This limitation is due to the switching loss in the transistor. The transistor switching loss increases with the switching frequency and thereby, the efficiency decreases. The core loss of the inductors limits the high frequency operation. Control voltage Vc is obtained by comparing the output voltage with its desired value. Then the output voltage can be compared with its desired value to obtain the contol voltage Vcr. The PWM control signal for the dc converter is generated by comparing Vcr with a sawtooth voltage Vr . There are four topologies for the switching regulators: buck converter, boost converter, buck-boost converter, cuck converter.

(a) Buck Converter

Buck converter consists of a transistor and diode that applies the supply voltage on an inductor capacitor, LC, circuit. The output voltage is the voltage across the capacitor.

The input voltage on the LC circuit is controlled by pulse width modulation, PWM. i.e. part of a cycle time, the voltage applied on the LC circuit is Vg and the rest of the cycle time the input voltage is zero. The range of duty cycle, d=[0, 1], is the relative time of the cycle time that the supply voltage is connected to the circuit, i.e. the input is Vg.

The duty cycle d is the control signal to the Buck converter. A circuit diagram can be seen in Fig 4.1.

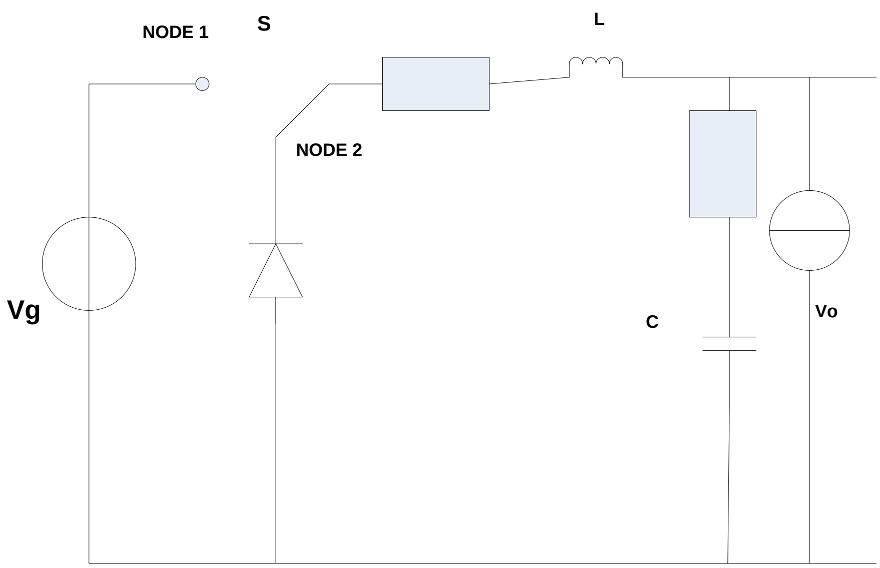


Fig 4.1: Circuit diagram of BUCK CONVERTER

The system need to be modeled to get the relationship between the input signal and output.

The Buck converter system is a switched system. It consists of two switching states: firstly, when the switch is connected to node 1, charging status; secondly, when the switch is connected to node 2, discharging status.

The switched system can be modeled as an averaged system. The averaged system describes the switched system up to about one tenth of the PWM frequency.

(B) BOOST CONVERTER AND ITS OPERATION.

It generates an AC output voltage larger than the DC input one, depending on the instantaneous duty cycle. This property is not found in the classical VSI, which produces an AC output instantaneous voltage always lower than the DC input one. For the purpose of optimizing the boost inverter dynamics, while ensuring correct operation in any working condition, a sliding mode controller can be used. The main advantage of the sliding mode control over the classical control schemes is its robustness for plant parameter variations, which leads to invariant dynamics and steady-state response in the ideal case operation, analysis, control strategy. The new inverter is intended to be used in uninterruptible power supply (UPS) and AC driver systems design whenever an AC voltage larger than the DC link voltage is needed, with no need of a second power conversion stage

It consists of a dc input voltage source Vg, boost inductor L, controlled switch S, diode D, filter capacitor C, and the load resistance R. When the switch S is in the on state, the current in the boost inductor increases linearly and the diode D is off at that time. When the switch S is turned off, the energy stored in the inductor is released through the diode to the output RC circuit.

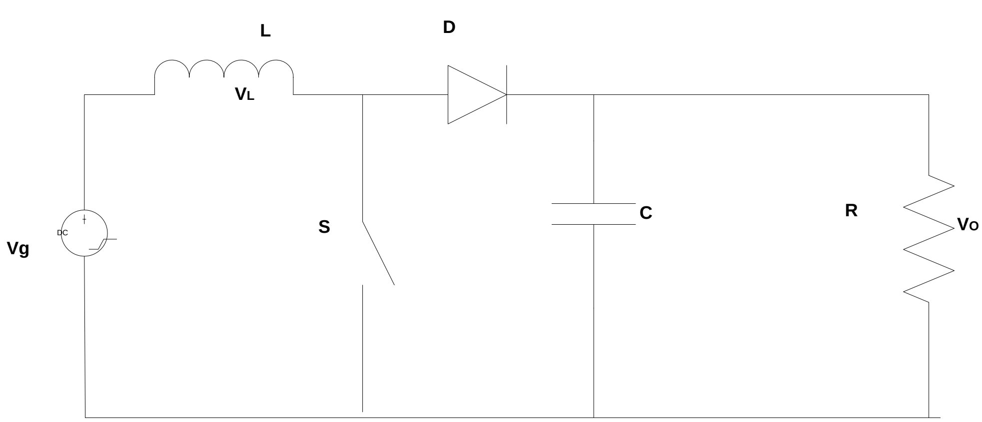


Figure 4.2: Circuit diagram of Boost converter

(C) Buck-boost converter

A buck-boost converter includes: a buck converter section including a first switch, a first rectifier, and an inductor; a boost converter section sharing the inductor and including a second switch, a second rectifier, and a smoothing circuit; and a control circuit for generating and outputting a first driving signal for opening and closing the first switch and a second driving signal for opening and closing the second switch. The control circuit includes: an error amplifier circuit for amplifying an error between an output value from the smoothing circuit and a predetermined voltage value to thereby generate and output an error signal; an oscillator circuit for generating and outputting a triangular wave signal having a predetermined cycle; a compensatory signal generation circuit for generating and outputting a compensatory signal, which oscillates in a cycle that is at least twice the cycle of the triangular wave signal; a control signal generation circuit for adding together the error signal and the compensatory signal to thereby generate and output a control signal; and a comparator circuit for comparing the triangular wave signal with the control signal to generate and output the first or second driving signal.

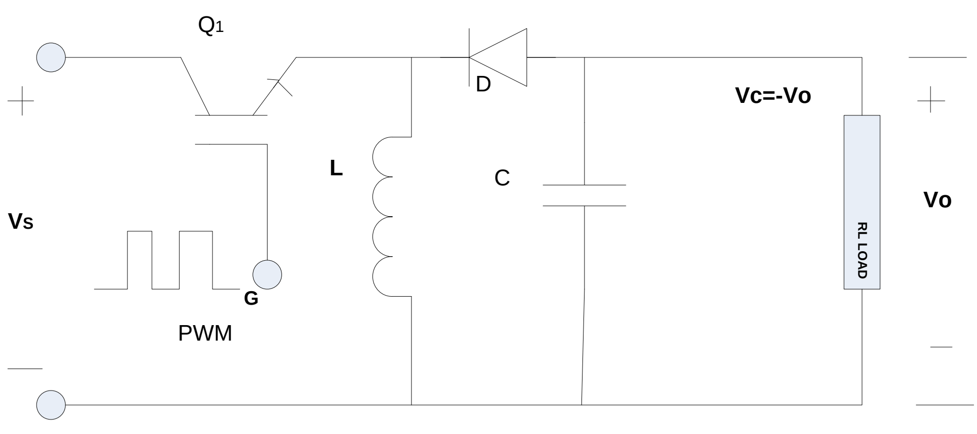


Figure 4.3: Circuit diagram of Buck-Boost converter

4.3 SYSTEM CONFIGURATION

The system configuration of the work is shown below in fig 4.5. It consists of +V Cell, DC-DC converter, LED light load and battery. There are three modes of operations. First mode when the available power from PV cell is more than that required for LED lighting and in this case, the battery will get charged i.e the solar power is used for lighting requirement as well as for charging of the battery. The Second mode is that during night hour when there is no solar power, the lighting load is powered from battery i.e battery is operating in discharging mode. The Third mode is that when the solar power is just sufficient to feed the lighting load i.e. no power is supplied from battery.

With these modes of operating, LED lighting load is fed by utilizing solar energy and also solar energy is stored in from of battery. This saves in the energy requirement taken from utility

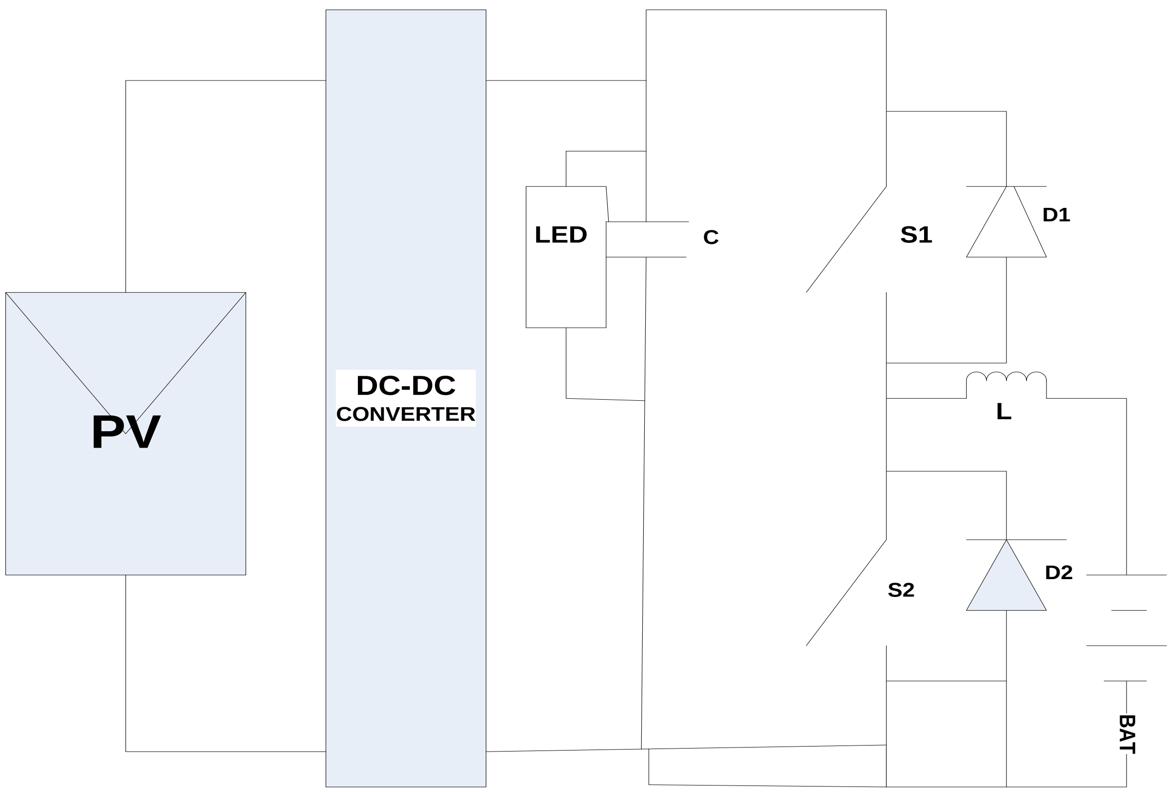


Fig 4.5 Block Diagram Of System Configuration

CHAPTER-5

MATLAB SIMULATION AND PERFORMANCE EVALUATION

The proposed LED lighting system utilizes hybrid sources via PV & battery for uninterruptable glow of LED Lighting system. The LED is being connected on common DC link feel both by PV & battery.

The PV system is inter faced via DC-DC boost converts as MPPT controller to the common DC link. Similarly the battery is being connected to common DC link via buck-boost converter. As for the need the battery right be operating in buck or boost mode to support the DC Link for constant flow of LED lights. The work of full system is disconnected under three modes as:

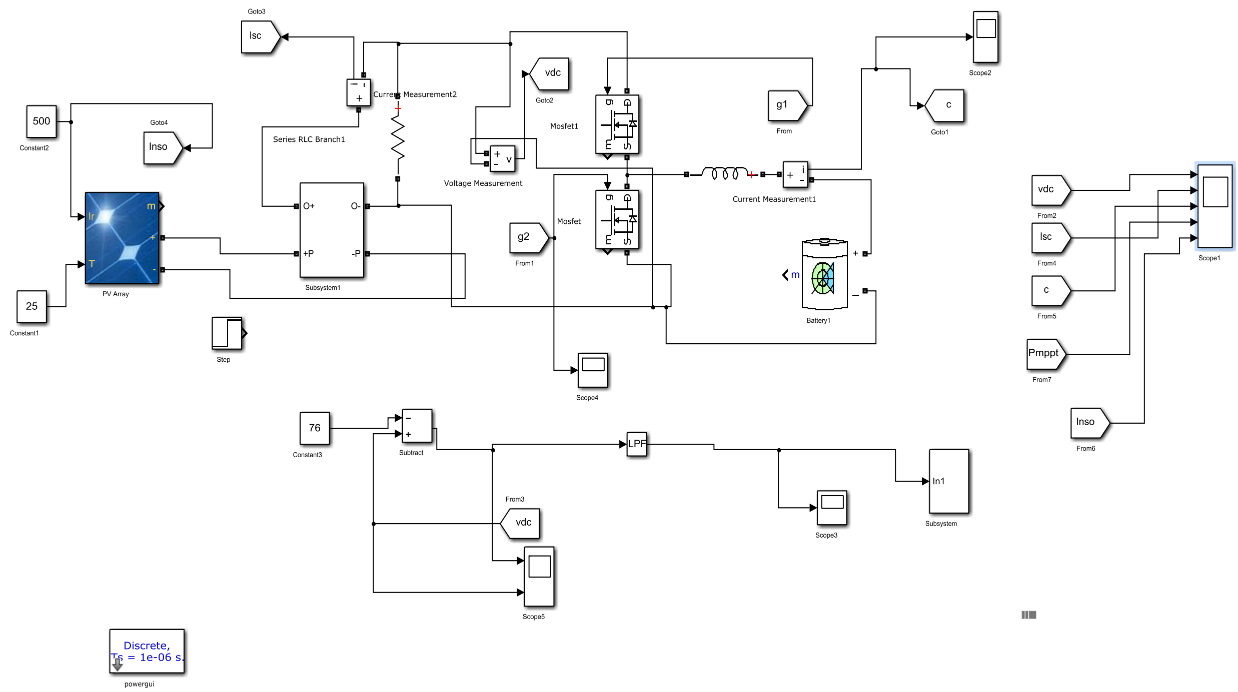


Fig.5.1(a): Block diagram of proposed system

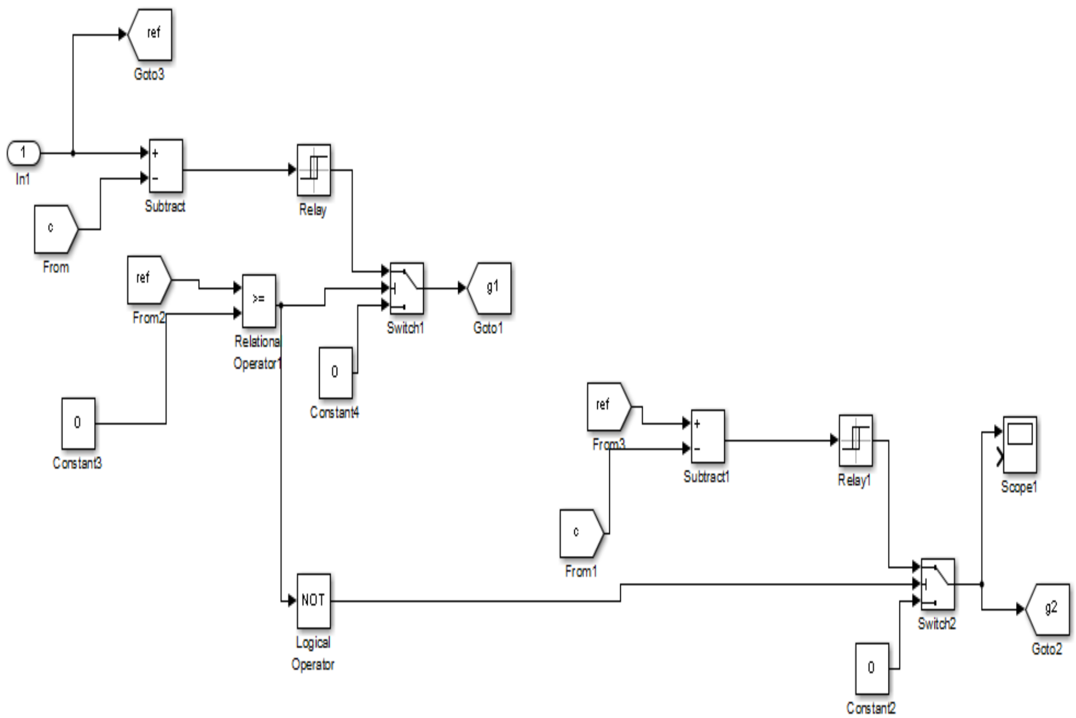


Fig. 5.2(b) : Block diagram of control circuit

(1) Mode-1:

In day time, when PV is producing more energy & energy is excess, the battery is being charged through Buck-Boost converter.

When MOSFET switch (1) is on & switch (2) is in off condition. The current flow path is shown in the Fig 5.2(a). the energy of the sales voltage source (i.e. 76 V constant) is transferred to the inductor & the battery.

Matlab Simulink graphs are shown as below:

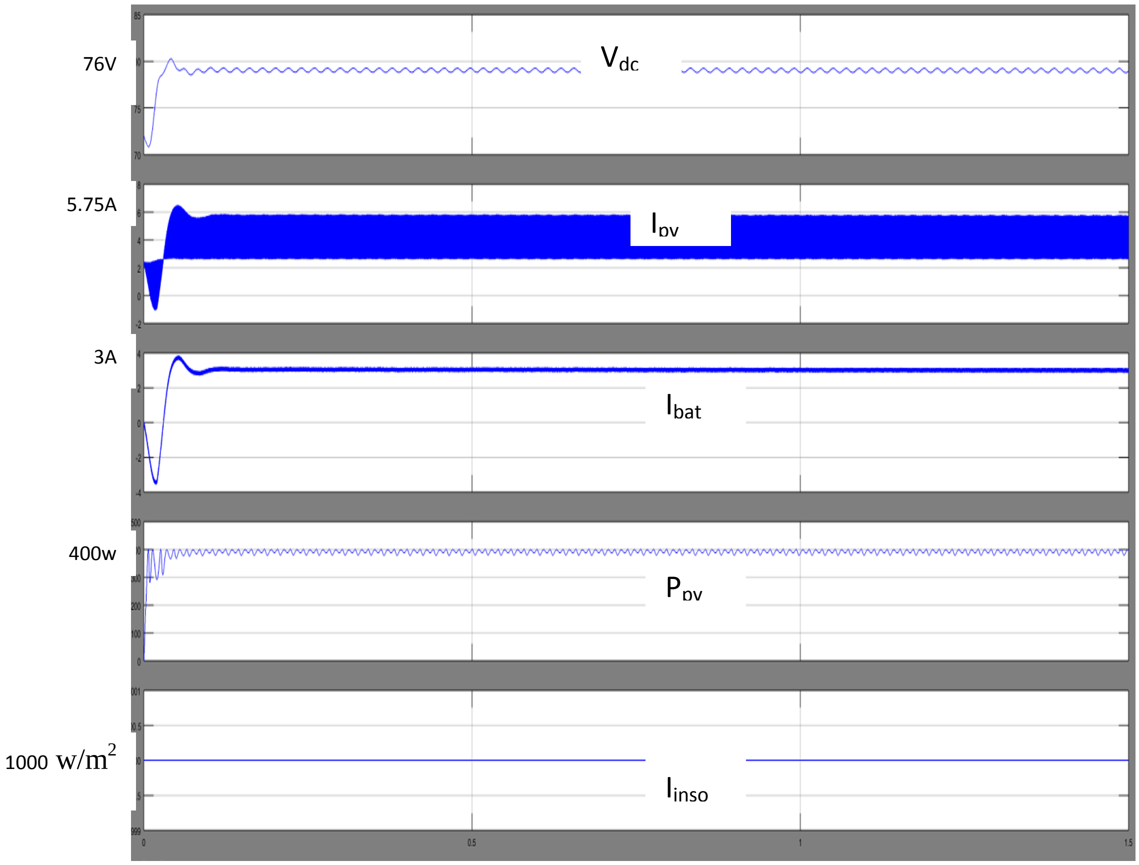


Fig 5.2(a): Matlab simulink graphs for DC link voltage, PV current, Battery current, PV power, Insolation current 1000 w/m^2

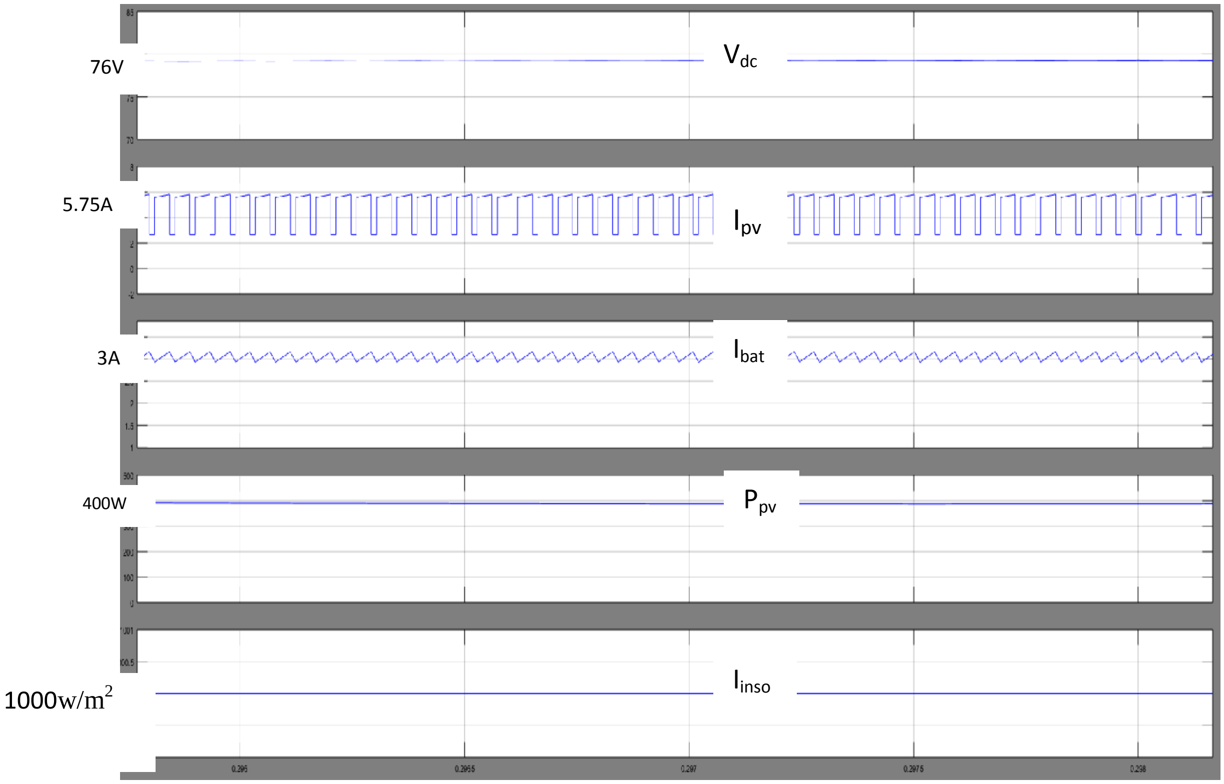


Fig 5.2(b):Zoomed: Matlab simulink graphs for DC link voltage, PV current, Battery current, PV power, Insolation current 1000 w/m^2

(2) Mode 2:

In night when battery is in operation i.e the energy stored in the battery is discharged to the LED through the 2nd converters

When MOSTET switch (1) is in off condition & switch (2) is on. The current path flow shown in figure. (i.e I= -1A)

The energy of the battery (i.e 48 V) is transferred to the inductor & energy stored ii discharged to the LED.

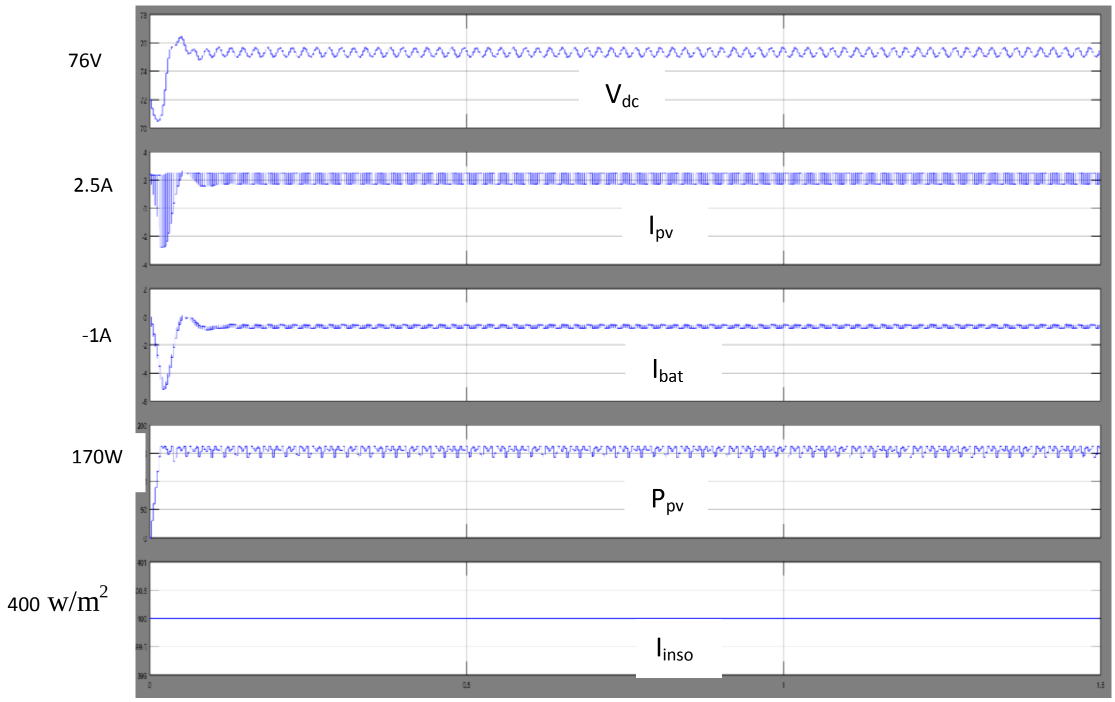


Fig 5.3(a): Matlab simulink graphs for DC link voltage, PV current, Battery current, PV power, Insolation current 400 w/m^2

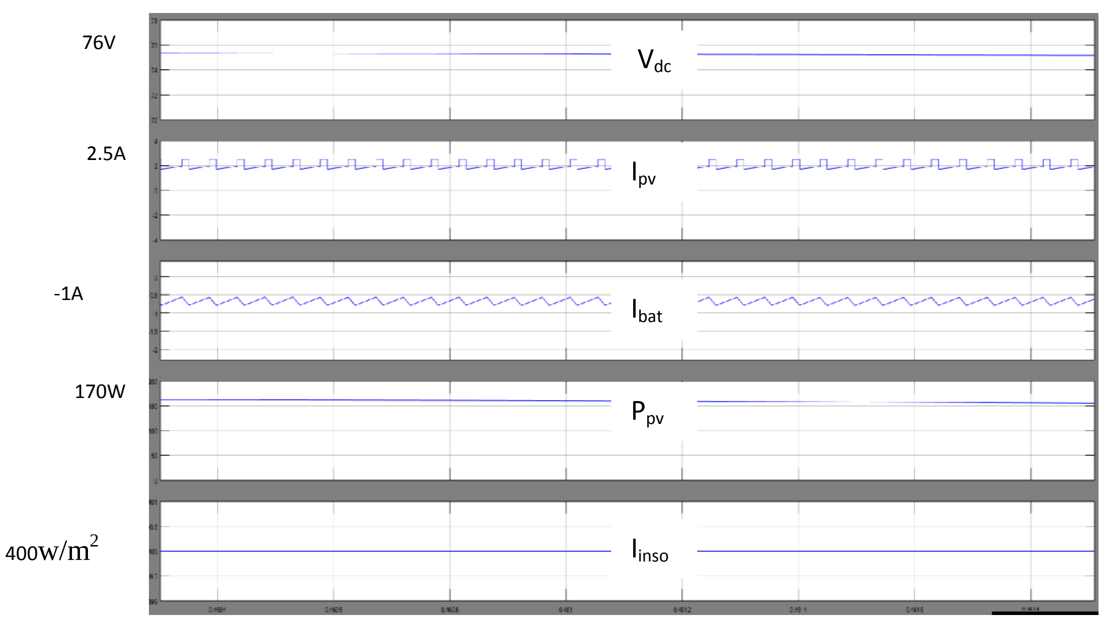


Fig 5.3(b):Zoomed Matlab simulink graphs for DC link voltage, PV current, Battery current, PV power, Insolation current 400 w/m^2

(3) Mode 3: When PV module produces energy is just sufficient to the load (ie~ 20 KW) & there are no battery charging or discharging.

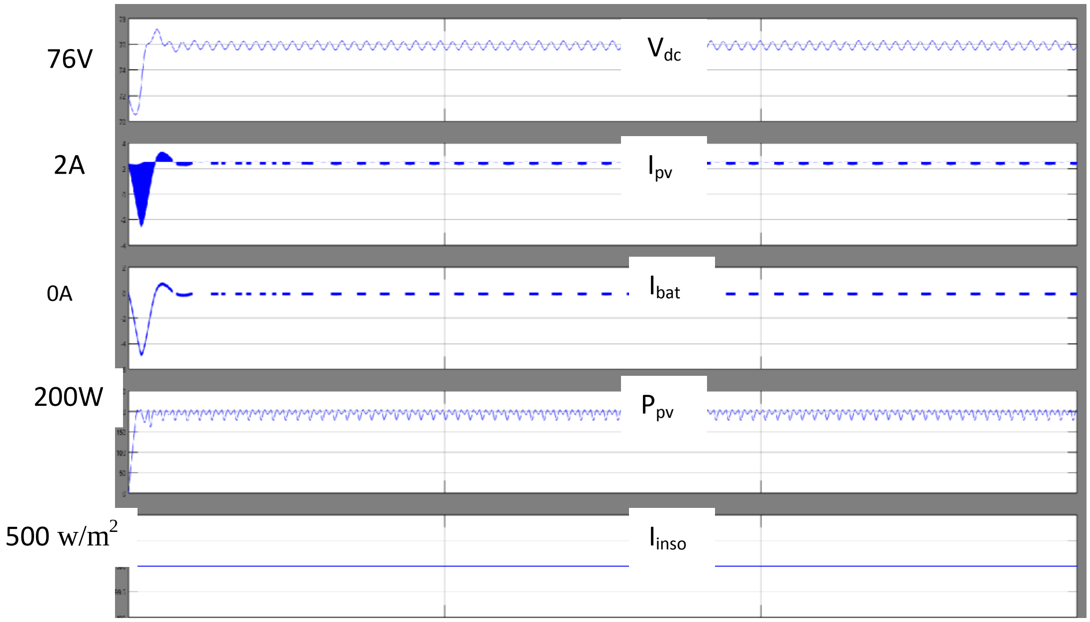


Fig 5.4(a): Matlab simulink graphs for DC link voltage, PV current, Battery current, PV power, Insolation current 500 w/m^2

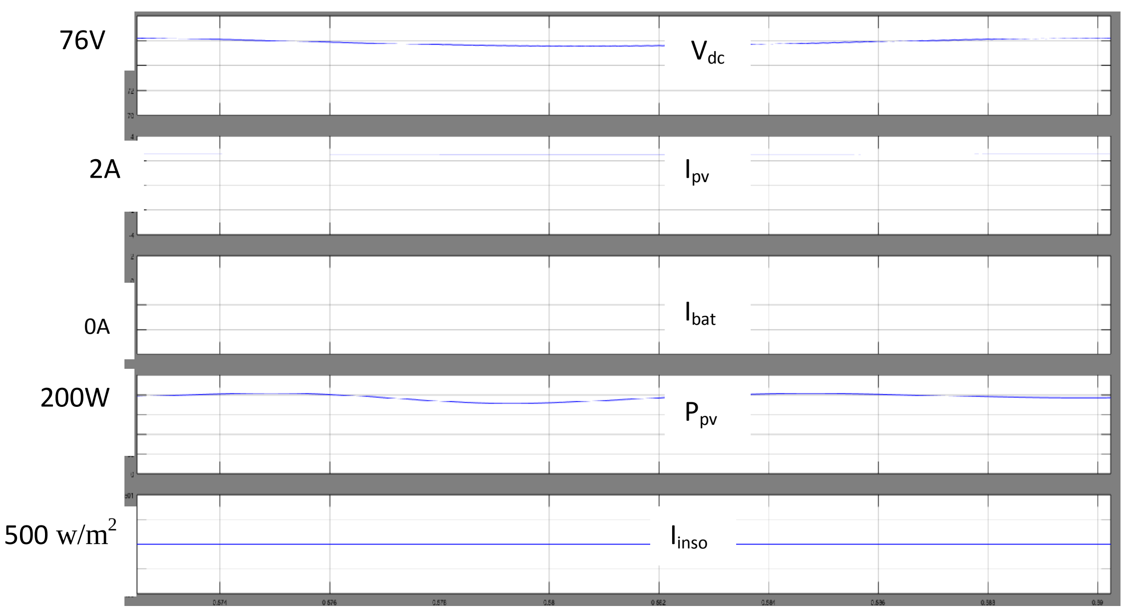


Fig 5.4(b): Zooomed Matlab simulink graphs for DC link voltage, PV current, Battery current, PV power, Insolation current 500 w/m^2

Simulation Result: as shown in the table below.

I_{inso} w/m^2	$V_{dc\ V}$	$I_{pv\ A}$	$I_{bat\ A}$	$P_{pv\ W}$
1000	76	5.75	3	400
400	76	2.5	-1	170
500	76	2	0	200

Table -5.5 Three modes variations with constant V_{dc}

CHAPTER-6
CONSTRAINTS/FEAR/ MYTHS

LED lighting field is mushrooming with many manufactures with unreliable LED chips/ devices and most of the manufactures claiming for pay-back period of 3 years. However, an analyses shows that payback period is about 5-7 years for DMRC. Now, with decreasing trend of LED lights prices, the payback period decreased to about 4 years. The reliability of products with manufacturers was a prime concern, so a policy was adopted that any manufacturer will supply LED lights with 5 years warrantee i.e. any light failed/ get defective, the same will be replaced/ make good by manufacturer free of cost, so that interest of organization is protected.

Secondly, for maintenance point of view, earlier is case of T-5 fitting, single tube was replaceable while now whole module is to be replaced & complete light fitting is to be taken out & replaced with good one. So now, on-site rectification of tubes accessory possible & so instead of accessories (tubes, chokes), whole light fitting is to be kept in spares.

6.1 ADVANTAGES:-

Inspite of reliability concerns of manufacturers & maintenance problems, the LED light fittings due to its obvious properties of high efficacy, long life time, CRI, size etc , DMRC successfully able to install the LED based lighting system at its upcoming metro stations.

Thus, the energy consumption got reduced by about 40%, this is only on account of lighting which is a great achievement and one of the major factor for having awarded its two stations (where LED lights installed) by IGBC as ‘Platinum’ rating.

Due to high efficiency, two upfront advantages are found :

1. Wastage of lights get reduced (Load reduction)
2. Number (Qty) of lights gets reduced due to increased inter light spacing.

CHAPTER-7

CONCLUSION AND FUTURE SCOPE OF WORK

From the investigations, it is concluded that the introducing of LED lighting system is rightly decided by DMRC resulting into about 40% of energy saving and also it reducing in connected load. This is beneficial for DMRC as the burning hours of lights here is more, ranges between 18-20 hours.

The study also concludes that there has been a vibrant changing and improvements came in the field of lighting applications by coming of LED lighting technology. LEDs due to its advantages of high efficiency, color rendering index, color temperature, size, robustness, reliability, luminous efficacy and longer lifetime have changed the lighting prospects and given a new dimension to energy saving aspects.

LED based lighting system are being successfully utilized in street lighting, mobile applications, IT applications in displays, high rise buildings and commercial hubs, personal digital assistance equipment in minimizing size and maximizing battery life like cell phone, TVs etc. Thus, there is broad scope of further developments in LED field due to always advancing technology. LED lighting system owing to its high efficiency play a major role in reducing lighting load demand and energy saving.

CHAPTER-8

PHOTOGRAPHS OF REPLACEMENTS

Double Height

(common area between platform and concourse)

Double Height

250W **165W with increased spacing**

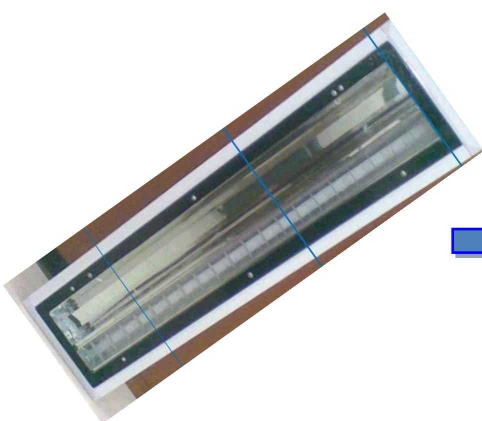
Concourse and platform

36W **32W(with increased spacing)**

Concourse

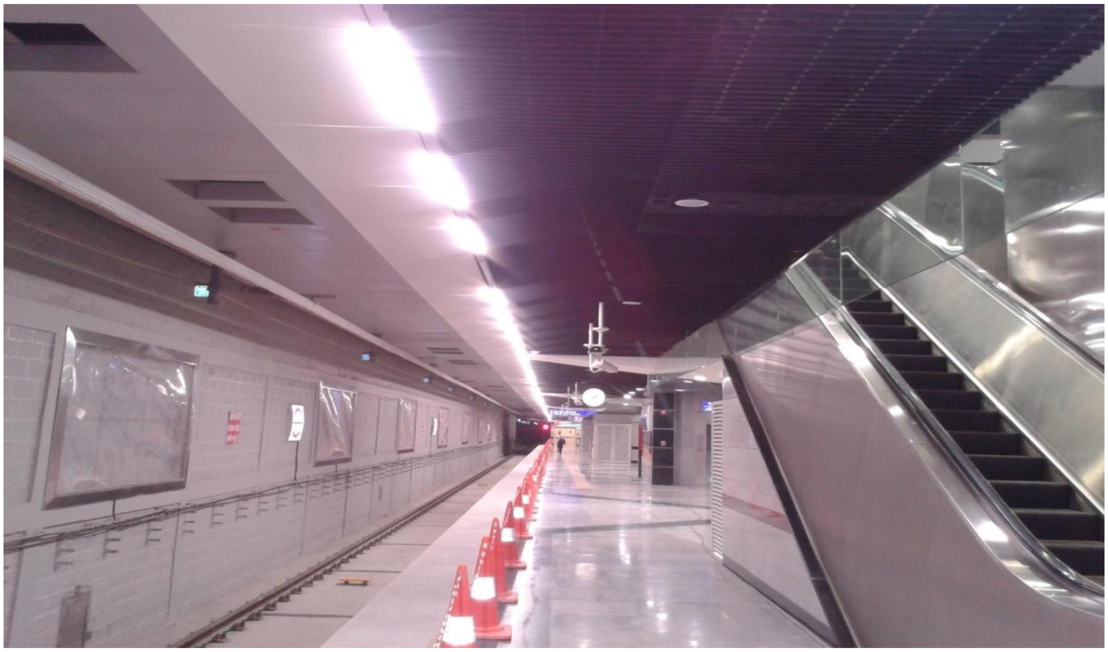
2X28W **2X18W**

Platform Edge Light



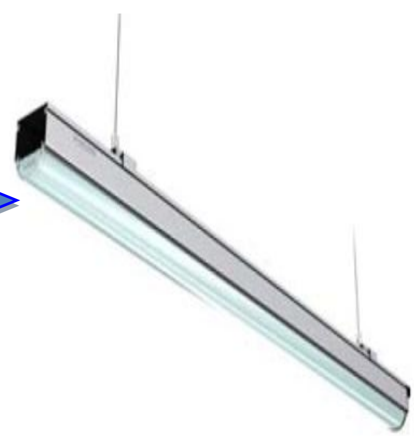
2X28W **40.8W with better lighting level**

Platform



Concourse

Subway and Entrances



2X28W **40.8W**

REFERENCES

1. Wensong Yu1, Member, IEEE Gianpaolo Lisi Evan Reutzel David Anderson Hongbo Ma “High Efficiency **DC-DC Converter** with Twin-Bus for Dimmable LED Lighting”.

2. P.S. Almeida, M.A. Dalla Costa, J.M. Alonso and H.A.C. Braga “Application of series resonant converters to reduce ripple transmission to LED arrays in offline drivers”.

3. Chia-Ching Lin*, Lung-Sheng Yang*, and En-Chih Chang** “Study of a DC-DC Converter for Solar LED Street Lighting”.

4. M. R. Cosetin, E. A. Bitencourt, T. E. Bolzan, M. F. da Silva, 1. M. Alonso* and R. N. do Prado FEDERAL UNIVERSITY OF SANTA MARIA - UFSM - BRAZIL*UNIVERSIDAD DE OVIEDO, DIEECS - TECNOLOGIA ELECTRONICA - SPAINAV. Roraima n° 1000 – Cidade Universitaria - Bairro CamobiSanta Maria, Brasil “Comparison of Integrated SEPIC-Buck and SEPIC-Cuk Converters as Offline Dimmable LED Drivers with Reduced Storage Capacitor”.

5. S. H. Chew1, K. J. Tseng 1,2+, Hoan Thong Nguyen2, 1School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore 639798 2Berkeley Education Alliance for Research in Singapore, CREATE TOWER, Singapore 138602 “An Energy Efficient 48Vdc Bipolar ELVDC LED Lighting System in a High-Rise Building”.

6. Amit Agrawal, Research Scholar Department of Electrical Engineering, India School of Mines Dhanbad, Jharkhand, India “A Review of Different DC/DC Converters for Power Quality Improvement in LED Lighting Load”.

7. David Gacio, Student Member, IEEE, J. Marcos Alonso, Senior Member, IEEE, Antonio J. Calleja, Member, IEEE,Jorge García, Member, IEEE, and Manuel Rico-Secades, Member, IEEE “A Universal-Input Single-Stage High-Power-Factor Power Supply for HB-LEDs Based on Integrated Buck–Flyback Converter”.

8. Cherl-Jin Kim 1*, Eung-Seok Kim 2, Heung-Kyo Shin 31,2Department of Electrical Engineering, Halla University, Wonju, Korea 3Department of Electrical Engineering, Gyeongsang National University, Jinju, Korea “A Study on the Power LEDs Drive Circuit Design with Asymmetrical Half-bridge Resonant Converter”.

9. K. Harish, H. Ranjith Kumar, Electrical Engineering Department, National Institute of Technology, Warangal, Warangal, India. “Study of a DC-DC Converter for LED Street lighting with ZCT using a single Auxiliary switch. Designing High-Efficiency LED Driver Circuits Using the NCL30051”.

10. Lu Liu, Wenxi Yao, Zhengyu Lu College of Electrical Engineering, Zhejiang University Hangzhou, China “Multi-Mode Control Strategy in Three-Level DC-DC Converter for Higher Efficiency Operation under Light-Load and Standby Conditions”.

11. Weiming Lin. Xu Yuzhen, QingLiang Zheng, Department of Electrical Engineer, Fuzhou University, Fuzhou 350108 P.R. China. “A High Efficiency Integrated Step-down Cuk and Fly back converter for LED Power driver”.

12. Yang Lu and Dariusz Czarkowski Polytechnic Institute of NYU 6 Metrotech Center

13. Brooklyn, New York 11201 USA “High Efficiency Adaptive Boost Converter for LED Drivers”.

14. Nikolay N. Goryashin1, Alexander S. Sidorov2, Anna S. Solomatova3 “LED Driver Based on Zero-Voltage-Switching Buck Converter with On-time Control”.

15. Wonkyeong Park, Van Ha Nguyen, Huynsik Son, Minji Lee, Hanjung Song Department of Nano Systems Engineering Gimhae 621-749, Republic of Korea “Design of a Step-Down DC-DC Converter for Mobile LED Applications”.

16. Ilya Galkin Institute of Industrial Electronics and Electrical Engineering Riga Technical University Riga, Latvia “Validation of Direct Current Control in LED Lamp with Non-Inverting Buck-Boost Converter”.

17. Chi-Yuan Huang1, Shu-Fen Kang, Chien-Hung Tsai2 Department of Electrical Engineering / Advanced Optoelectronic Technology Center (AOTC)/ Green Energy Electronics Research Center (GREERC) National Cheng-Kung University, Tainan, Taiwan, R.O.C. “Design and Implementation of a Current-Mode DC-DC Converter for LED Driving”.

18. J. Cardesín, D. García-Llera, E. López- Corominas, A.J.Calleja, J. Ribas. University of Oviedo IEEE Member – Ce3i2 group Asturias-Spain “Low cost intelligent LED driver for public lighting smart grids”.

19. Giovanni Calisse, Gionata Cimini, Luigi Colombo, Alessandro Freddi,Gianluca Ippoliti, Andrea Monteriu and Matteo PirroDipartimento di Ingegneria dell'Informazione, Universita Politecnica delle MarcheVia Brecce Bianche 12, 60131, Ancona, Italy “Development of a Smart LED Lighting System: Rapid Prototyping Scenario”.

20. Weiming Lin, Xu Yuzhen, QingLiang Zheng, Department of Electrical Engineering, Fuzhou University, Fuzhou 350108 P.R. China. “A High Effieincy Integrated Step-down Cuk and Flyback convertger for LED Power driver”.

21. DMRC energy management policy a way forward-2016.

22. Manual on illumination for Metro Systems of DMRC.

23. Outline Design Criteria (ODC) of DMRC.

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