DEVELOPMENT COST-EFFECTIVE SOLAR LED STREETLIGHT AT KOLEJ KEMAHIRAN TINGGI MARA PASIR MAS

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requirements for the award of the degree of
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DEDICATION

I would like to dedicate this to my beloved mother and father, my lovely husband, family, friends and lecturers

Thanks for everything

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Praise to be Allah, I am grateful to dear Allah for His Graciousness and blessings that I finally managed to complete this research and project report after going through the challenges and anticipations.

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Last but not least, thank you so much to anyone whom had helped me whether directly or indirectly throughout the journey of completing this thesis and my master degree.

ABSTRACT

The demand to seek new renewable energy sources for electricity has been rising. Therefore, solar street lighting system is an effective way to reduce power consumption and CO2 impact on the environment with the maintenance of the safety standards of the road. Roads are significant facilities of local municipalities and their lighting systems. Most conventional street lighting systems are turned on/off regularly. The result is that if there is low road traffic, a large part of electricity consumed by street lighting will be wasted. Automated street lighting system attracts a lot of worldwide interest due to the growing demand for global energy use and the green environment. In this research, a cost effective and energy efficient automated street light control based on PIR motion sensor and timer is proposed. The streetlight is automatically controlled with the motion the road pedestrian near to the streetlight. This system uses photovoltaic (PV) as main supply, battery as storage supply and fuel cell (FC) as backup supply. In lighting side, Light Emitting Diode (LED) is used and dimmed with control by relay. The design uses 250W solar panel with 8A x 31.25V (200Ah) battery. The system has the design capability to last for 12 hours per day and controlled by timer. The method using is by calculate and compute the load profile (LED bulb used), hours of usage, Ah for battery storage, sizing solar panel charger controller rating will be analyzed to optimized usage in solar LED streetlight system. Furthermore, the total consumption of streetlight solar system will be analyzed and show by graph. Hence the loss of energy due to unnecessary glow of the streetlights can be avoided and it will bring considerable economic benefits. Solar LED Streetlight system thus reducing the cost further, and a more energy-efficient system are achieved. An economic analysis is also performed to determine the cost effectiveness of the cost installation is found to be RM 1896.00 for 1 pole streetlight comparing the conventional streetlight is found RM 2650.00 which is equivalent to 39.77%. Proposed system can be saving energy consumption 1200W for 1 pole within 12 hours per day.

ABSTRAK

Permintaan untuk mencari sumber tenaga baru yang boleh diperbaharui untuk elektrik semakin meningkat. Oleh itu, sistem lampu jalan suria adalah kaedah yang berkesan untuk mengurangkan penggunaan tenaga dan kesan CO2 terhadap alam sekitar dengan pemeliharaan piawaian keselamatan jalan raya. Jalan raya adalah kemudahan penting bagi perbandaran tempatan dan sistem pencahayaannya. Kebanyakan sistem lampu jalan konvensional dihidupkan / dimatikan secara berkala. Hasilnya adalah jika jalan raya rendah, sebahagian besar elektrik yang digunakan oleh lampu jalan akan terbuang. Sistem lampu jalan automatik menarik banyak minat di seluruh dunia kerana permintaan yang semakin meningkat untuk penggunaan tenaga global dan persekitaran hijau. Dalam penyelidikan ini, cadangan lampu jalan automatik yang menjimatkan dan menjimatkan tenaga berdasarkan sensor gerakan PIR dan pemasa dicadangkan. Lampu jalan dikawal secara automatik dengan gerakan pejalan kaki jalan berhampiran lampu jalan. Sistem ini menggunakan fotovoltaik (PV) sebagai bekalan utama, bateri sebagai bekalan simpanan dan sel bahan bakar (FC) sebagai bekalan sandaran. Di sisi pencahayaan, Light Emitting Diode (LED) digunakan dan dimalapkan dengan kawalan oleh geganti. Reka bentuknya menggunakan panel solar 250W dengan bateri 8A x 31.25V (200Ah). Sistem ini mempunyai kemampuan reka bentuk untuk bertahan selama 12 jam sehari dan dikendalikan oleh pemasa. Kaedah yang digunakan adalah dengan mengira dan mengira profil beban (lampu LED yang digunakan), jam penggunaan, Ah untuk penyimpanan bateri, ukuran pengawal pengecas panel solar ukuran akan dianalisis untuk penggunaan yang dioptimumkan dalam sistem lampu jalan LED solar. Selanjutnya, jumlah penggunaan sistem solar lampu jalan akan dianalisis dan ditunjukkan mengikut grafik. Oleh itu, kehilangan tenaga kerana cahaya lampu jalan yang tidak perlu dapat dielakkan dan akan membawa faedah ekonomi yang besar. Sistem Lampu LED Suria sekali gus dapat mengurangkan kos lebih jauh, dan sistem yang lebih cekap tenaga dapat dicapai. Analisis ekonomi juga dilakukan untuk menentukan keberkesanan kos pemasangan kos didapati RM 1896.00 untuk 1 tiang lampu jalan yang membandingkan lampu jalan konvensional berjumlah RM 2650.00 yang bersamaan dengan 39.77%. Sistem yang dicadangkan dapat menjimatkan penggunaan tenaga 1200W selama 1 tiang dalam tempoh 12 jam untuk sehari.

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LIST OF ABBREVIATIONS

PV	-	Photovoltaic
PWM	-	Pulse Width Modulation
MPPT	-	Maximum Power Point Tracker
BMS	-	Battery Management System
C	-	Capacitance
DC	-	Direct Current
LEDs	-	Light Emitting Diodes
PIR	-	Passive Infrared Sensor
HID	-	High Intensity Discharge
F	-	Frequency
HPS	-	High-Pressure Sodium (HPS)
I	-	Current
LDR	-	Light Dependent Resistor
IMB	-	Internal Module Balancing
M	-	Module
Ni-Cd	-	Nickel Cadmium
Ni-MH	-	Nickel Metal Hydride
Li-ion	-	Lithium Ion
Li-ion P	-	Li-Ion Polymer
R	-	Resistor
UPS	-	Uninterruptible Power Supply
CO2	-	Carbon Dioxide
T	-	Temperature
UC	-	Unidirectional DC-DC Converter
V	-	Voltage

LIST OF SYMBOLS

τ	-	Time Constant
T	-	Period
γ	-	Angle of incidence
E_P	-	Illuminices
C	-	Degree
H	-	Height
kW	-	kilowatt

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The existence of global streetlight market is estimated at approximately US$6.28 billion and is projected to expand over the 2020-2027 forecast period at a healthy growth rate of over 16.13 percent [1]. For outdoor street lights, Solar Street Lights (SSL) are typically used because solar energy is the key source of energy. Without depending on conventional energy sources, these lighting function in an autonomous mode, thereby removing the need for a general grid with any power requirements. The stand-alone solar panel street light system comprises a rechargeable lead-acid storage battery, a battery-charging, a light source (compact fluorescent lamp) and a light-emitting diode (LED), suitable electronic devices for tampering and safe charging and unloading of battery systems and mechanical hardware to fix these subsystems.

In the residential, industrial, and manufacturing sectors, solar street light systems are used. Among these, as more and more steps are being taken by the government and local authorities to use solar lighting, the commercial sector is expected to lead the global market. In highways, roads, and several other commercial areas, solar street lighting systems are currently being used. Development in this sector has also been encouraged by the rising demand for solar lighting in parking lots, highways, subways, surrounding security lighting and public area lighting[2].

Global citizens are becoming increasingly aware of the burden of using conventional light sources, which has led them to turn to solutions that are more environmentally friendly. In addition, a letter of intent for cooperation with the aim of building a smart city in Kota Kinabalu, the capital of Sabah, Malaysia, was signed by South Korea and Malaysia in September 2018[3]. As a result, the global demand for LED lighting is rising to enhance the urban environment and improve energy efficiency. Smart solar LED streetlights have gained extensive attention in the field of green energy compared with conventional streetlights. Because of its remarkable features, such as solar LED streetlights independent of the public grid, it is common and commercially used[4]. Therefore, solar LED streetlights need much less maintenance compared with conventional streetlights. Driven lighting, however, offers strong prospects for ventures in street lighting.

The research of this development of a new lighting system on the street is to obtain efficient methods for develop solar LED streetlight in Kolej Kemahiran Tinggi MARA Pasir Mas. This allows for the more sustainable use of small battery storage energy. In Figure 1.1, show the solar LED streetlight block diagram.

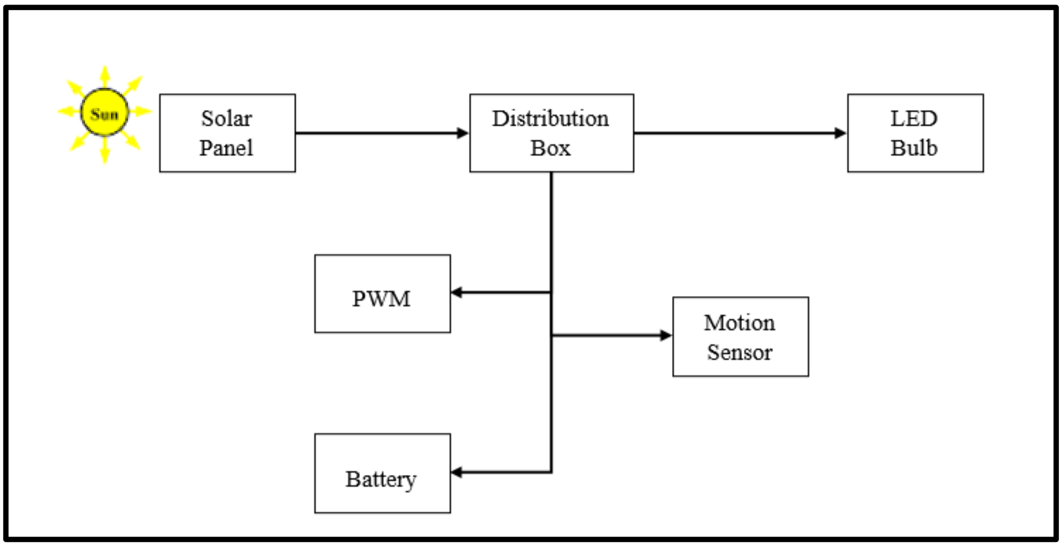

Figure 1.1 Solar LED Streetlight Block Diagram

1.2 Problem Statement

The new street lighting activity is also deemed not to be energy-efficient and cost-effective. In all aspects, especially solar panels and batteries, this scenario has an impact on increased cost. In Kolej Kemahiran Tinggi MARA Pasir Mas, conventional streetlights are still used, which raises the energy bill and the availability of TNB electricity for full use. Hence, maintenance cost every year is costly. Thus, mostly in Kolej Kemahiran Tinggi MARA Pasir Mas using conventional street lighting not LED lamp. Therefore, traditional streetlights do not use sensors to regulate luminosity. These are problems are occurred and to overcome this matter by delopement solar LED streetlight are developed.

1.3 Objectives of Reasearch

The objective of the research are formulated :

i. To model and simulate the LED streetlight system using solar panel.
ii. To design and develop the solar streetlight LED at Kolej Kemahiran Tinggi MARA Pasir.
iii. To perform economic analysis of the proposed system.

1.4 Scope of Work

In this work, there are many methods of develop solar LED street lighting have been proposed and reviewed. The scope of the works consists of 250W Polycrytalline solar panel, 12/24V~ 30A PWM Charger Controller, 50W/pair and 40W/bulb MINI LED Headlight, 12V 200AH Reachargeable Lead Acid Battery and DC 12V/180 degree Motion Sensor. This work on develop solar LED streetlight was implementation near Surau Arrayan at Kolej Kemahiran Tinggi MARA Pasir Mas, Kelantan. Thus, calculation on equipment based on research, modelling and simulation are created by using Simulink Matlab to ensure the system will operate smoothly before it structured. Then, when the simulation was successful the structure for proposed system are developed.

1.5 Significant of Work

It is a concern where anything that development solar LED streetlight in Kolej Kemahiran Tinggi MARA Pasir Mas will give environment technology such as green technology where can save energy. Many manufacturers are unveiling next-gen solar-powered street lights and designers are coming up with even better lighting solutions for the future. Boosting this green trend, street lighting systems that can make streets green and safe. Nowadays, information can be *sp*read out easily with the help of technological devices and the awareness on solar energy LED streetlight by the public might cause a doubt in the quality of solar panel supply in the market whether it contain high level of contaminant or not. By conducting research in this field, it may help better understanding on the physical characteristics of solar panel, charger controller, types of battery used in solar and most importantly aid knowledge in order for the all Kolej Kemahiran Tinggi MARA(KKTM) and Institut Kemahiran MARA (IKM) in Malaysia also included Sabah and Sarawak. In general, this reaserch will add in knowledge on the occurrence of develpement solar LED streetlight in Kolej Kemahiran Tinggi MARA Pasir Mas and information provided from this study can serve as a baseline data for understanding on the extent of solar LED streetlight for reference other institution in Majlis Amanah Rakyat (MARA) organization.. By research , calculation on equipment, design and implemet and result of solar LED streetlight successfully develod in Kolej Kemahiran Tinggi MARA Pasir Mas.

1.6 Thesis Outline

This study comprises five chapters, each of which addresses various subjects, as described. In chapter 1-introduction will discuss the fundamental principles of the solar panel, its components, and its significance will be presenting in this chapter. The objectives and scope are mentioned to provide an explanation of the purposes and shortcomings of the study project.

All components such the solar panel, charger controller, battery, timer, sensors, and LED light suggested by different researchers are explored in types, size, and design in chapter 2 , including their objectives, control of intensity, circuit of street lighting, size, benefits, and previous applications. Details block diagram, schematic and design of development cost- effective solar LED streetlight at Kolej Kemahiran Tinggi MARA Pasir Mas will present in this chapter 3.

Results and discussion will discuss in chapter 4. This chapter presents the results of the solar LED street lighting will be presented. Last, based on the analyses and discussions provided in Chapter 4, Chapter 5 draws conclusions. In addition, the *Development Cost- Effective Solar LED Streetlight at Kolej Kemahiran Tinggi MARA Pasir Mas* will be concluded and outlined here.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the result and structure system, it can be concluded that Development Cost-Effective Solar LED Streetlight at KKTM Pasir Mas were very successful with functional very well. It can be concluded as follows.

i. Electricity bills can be reduce compare as before. Not only that, the results more positive where do estimate cost overall KKTM's and IKM's in Malaysia. Therefore, objective to reduce bills electricity in KKTM Pasir Mas, Kelantan was achieved.

ii. The maintenance cost will save because to maintenance the proposed system over 20 years regarding standard of solar panel lifetime. Thus, saving maintenance cost was achived.

iii. Lastly, by using LED light more LED lights reach full brightness instantly - They do not require time to warm up, which makes them a flexible light source. Far more environmentally friendly - They do not contain lead or mercury and do no mit any poisonous gases. They also give off less CO_2 emissions. So, the objective was achieved.

5.2 Recommendation

There are some recommendations that were identified and can be done to improve the findings for future study:

i. Smart Solar Street light LED will can improve by add wind energy as additional sources energy to generates power to supply for this system during weather is raining or monsoon season especially in KKTM Pasir Mas , Kelantan.

ii. Centralized solar PV system is strongly recommended because to this type of street lighting scheme, site specific detail technical survey and design has to be carried out. The centralized system power output shall be of AC power and therefore the selected LED lamp must be of AC type. In centralized system, arrays of PV panels will be fixed at a convenient location and the power output from the source is distributed to the lights in a particular group via distribution cables. For this type of lighting system, since the battery will be installed at one place as one battery bank, use of flooded tubular deep cycle battery in addition to the battery type (Gel Tubular and LI Ion) can also be used.

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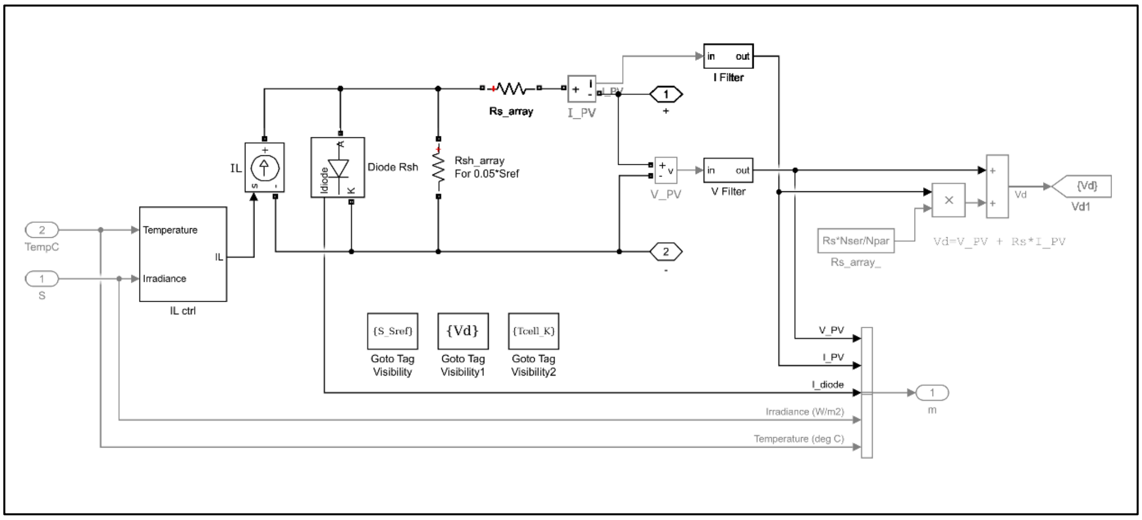
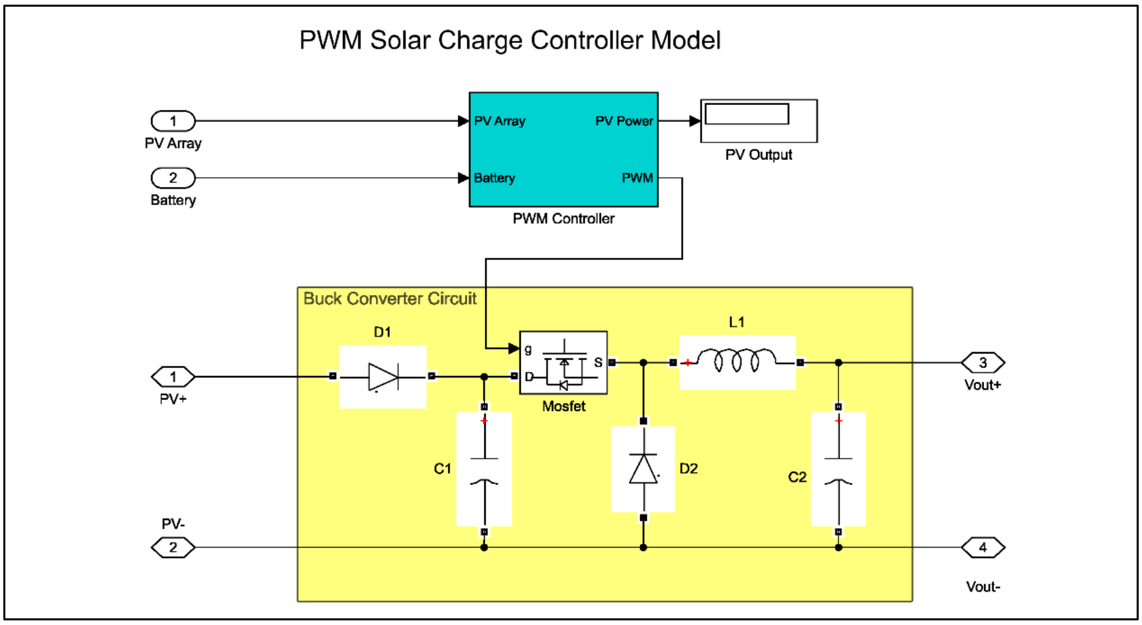
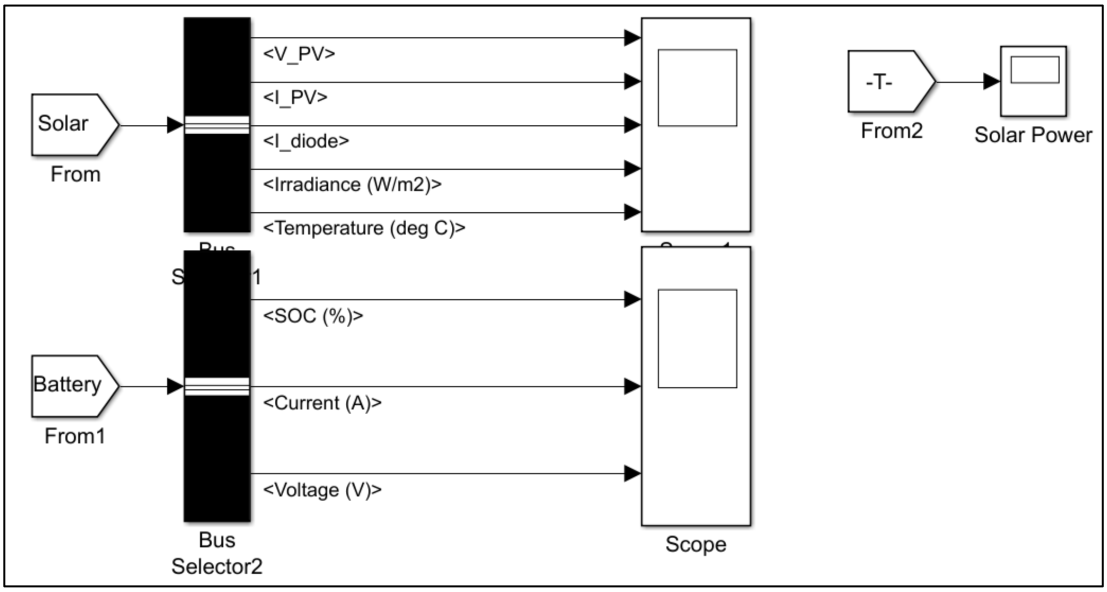
Appendix A Schematic Modelling In MATLAB Simulink



Schematic PV Array 250W by using MATLAB Simulink



Schematic PWM Charger Controller by using MATLAB Simulink



Parameters to show the output from Solar and Battery

Hardware Spesification

i. Solar

Solar

Material	Polycrystalline Silicon
Max. Power	250W
Open-circuit	37.56V
Max. Power Point Voltage	31.44V
Short-circuit current	8.59A
Number of Cells	Max. Power Point Current: 7.95A 1640 x 990 x 40mm Silver/ Blk Anodized Aluminum
Solar Panel Frame	60 pcs
Solar Panels Glass	3.2mm, High Transmission, AR Coated Tempered Glass

ii. LED Lamp

LED lamp

Manufacturer Part Number	MINI1 LED headlight
Wattage	100W/Pair , 40W/Bulb
Hight luminous efficacy Flux	6000LM/Pair 3000LM/Bulb
Waterproof	IP68
Voltage	9V to 36V. Wide-range voltage constant current control anti-interference circuit design
Long range	6000K color temperature and 200m light range

iii. Battery Lead Acid

Baterry Lead Acid

Battery Spec	12V 200AH
Boost/Equalize	14.5-15V
Float	13.5-13.8V
Max Charging Current	60 A
Dimension	W/O Terminal – 52.5cm*20.5cm*21.5cm With Terminal - 52.5cm*20.5cm*23cm
Net Weight (kg)	53.00
Gross Weight (kg)	54.00
Packaging	55.7cm*23.4cm*28.1cm

iv. PWM Charger Controller

PWM Charger Controller

Current	30A
Voltage	12V
Power	360W
USB Output	5V / 3A
Nett Weight	130G +-
Gross Weight	155G+-
Box Size (MM)	140x80x40

v. Timer

Timer

Standard working power supply	**DC 12V/24**
Timer Range	1 mins – 168 hours
Regular Timer	16 Times ON/OFF(day/weeks)
Time error	<1S/day (25℃)
Dimension	99*56*42mm
Weight	130g - Have Hibernation feature

vi. Breaker 2 Pole

Breaker 2 Pole

Rated Voltage	**DC 250V**
Current Rating	32A
Number	2P
Dimension	18L X 40W X 77H (mm)Y

vii. Motion Sensor / PIR Sensor

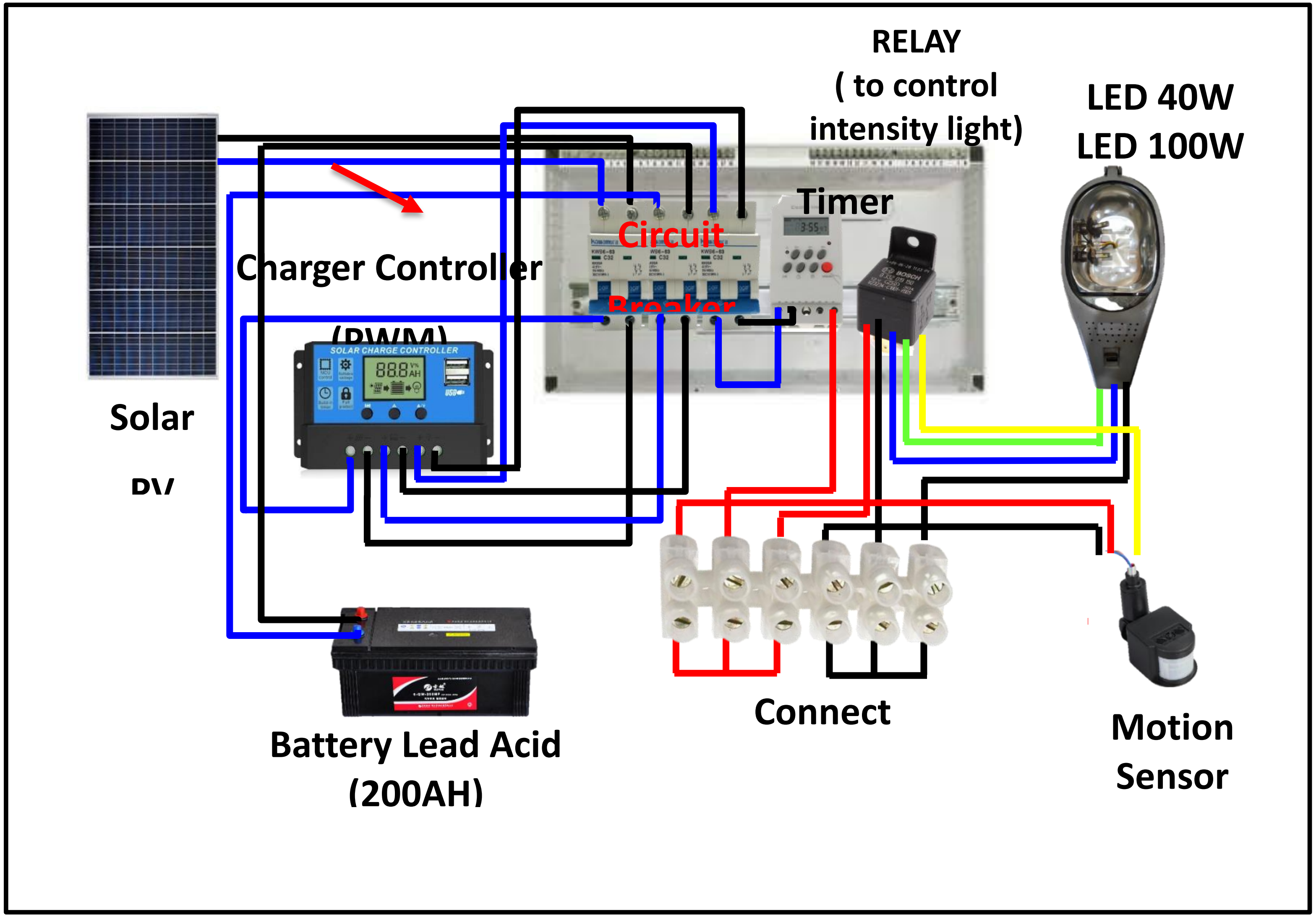
Motion Sensor / PIR Sensor

Color	Black
Material	ABS
Working Rotation	180 Degree
Voltage	DC 12V
Standard	LVD, EMC, CE, RoHS
IP Rating	Indoor application IP44
LUX Setting	2-2000lux svr adjustable
Size	As shown on the picture Induction
Lighting	5s~6min adjustable time
Detection Distance	Approx 12M, installation 1.5-2.5M

viii. Relay

Relay

Color	Black
Designation	Mini-Relay
Norminal Current	30A
Norminal Voltage	12 V
Number of Poles	5
Supplementara article / info	With holder
Switch function	NO Contact
Temperature range [C]	- 40 ...+ 100C
Type of housing	Plastic


RELAY
(to control
intensity light)
LED 40W
LED 100W
Timer
Circuit
Breaker
Charger Controller
(PWM)
SOLAR CHARGE CONTROLLER
Solar
PV
Battery Lead Acid
(200AH)
Connect
Motion
Sensor

BIL	HURAIAN	UNIT	KADAR HARGA (RM)
	E) PEMASANGAN LAMPU JALAN/TAMAN BARU (Samb)		
A	Membekal dan memasang tiang jenis *spun* konkrit bulat tirus ketinggian 8/9m termasuk mengorek, menegak dalam tanah dan mengambus serta lain-lain aksesori kelengkapan berkaitan mengikut arahan Pegawai Penguasa atau Wakil Pegawai Penguasa.	No	1,060.00
	Membekal dan memasang tiang lampu jalan dekoratif baru atau mengganti tiang-tiang yang rosak/dilanggar jenis l/d lelengan (*arm* sehingga 3m bersama kelengkapannya mengikut arahan Pegawai Penguasa atau Wakil Pegawai Penguasa;		
B	4 meter	No	1,802.00
C	6 meter	No	2,650.00
D	8 meter	No	3,180.00
E	10 meter	No	4,028.00
F	12 Meter	No	4,770.00
G	Membekal Pre-Cast Concrete Footing saiz 500mm x 500mm x 1500mm tapak asas konkrit untuk tiang lampu jenis berbibir (*flanged mounted*) mengikut spesifikasi saiz ukuran standard (*ready made*) mengikut arahan Pegawai Penguasa atau Wakil Pengawai Penguasa.	No	553.00
H	Pendakap lekapan jenis *hot dipped galvanised* sesuai untuk lantera (*short arm*) termasuk alat lengkap.	No	80.00
J	Pendakap lekapan (*T-bracket/head frame*) jenis *hot dipped galvanised* sesuai untuk lantera lampu limpah termasuk aksesori.	No	345.00
K	Pendakap lekapan (*O-bracket*) jenis *hot dipped galvanised* sesuai untuk lantera lampu limpah termasuk aksesori.	No	742.00
L	Membekal dan memasang *bracket arm* (1.5 meter) dan segala kelengkapan untuk pemasangan lantera di tiang konkrit TNB mengikut arahan Pegawai Penguasa atau Wakil Pegawai Penguasa.	No	153.00
M	Membekal dan memasang set kelengkapan pada tiang konkrit (*Dead-end Clamp, J-Hook, Suspension*) untuk perjalanan ABC kabel dari tiang ke tiang dan lain-lain aksesori kelengkapan berkaitan mengikut arahan Pegawai Penguasa atau Wakil Pegawai Penguasa	Set	65.00
N	Pendawaian dalaman untuk lampu dari *service door* ke lantera.	Set	53.00
P	Membekal *Black Box Fuse* untuk pemasangan lampu di tiang konkrit TNB	Set	400.00
Q	Membekal dan memasang penutup *Feeder Pillar* bagi saiz bersesuaian untuk *Feeder Pillar* lampu jalan/lampu taman yang berfungsi sebagai 'anti vandalisma' sebagaimana arahan Pegawai Penguasa atau wakil Pegawai Penguasa.	No	1,590.00

Appendix B Others

BIL ELEKTRIK ANDA

No. Ak [redacted]
No. Ko [redacted]
Deposi [redacted]
No. Inv [redacted]

TUAN PENGETUA INSTITUT KEMAHIRAN MARA

KG APAM
LUBOK JONG
17000 PASIR MAS
KELANTAN

TENAGA NASIONAL

TERIMA KASIH Kerana Membayar Dalam Tempoh 30 Hari

TNB Careline 1-300-88-5454

Jumlah Perlu Dibayar : RM 20,697.95 | **Tarikh Bil : 01.05.2021** | **Bil : LPC**

		Amaun	Bayar Sebelum		
Tunggakan	RM	0.00	Terima Kasih		
Caj Semasa	RM	20,697.97			
Penggenapan	RM	-0.02			
Jumlah Bil	RM	20,697.95	31.05.2021		
Bil Terdahulu (01.04.2021)	RM	31,728.10	Bayaran Akhir (20.04.2021)	RM	31,728.10

Jenis Bacaan : Bacaan Sebenar
Tempoh Bil : 01.04.2021 - 30.04.2021 (30 Hari)
Tarif : B:Perdagangan

Blok Tarif (kWh)	Kegunaan (kWh)	Kadar(RM)	Amaun(RM)
200	200.00	0.4350	87.00
>200	41,464.00	0.5090	21,105.18
Jumlah	41,664.00		21,192.18

Untuk maklumat bil dan bayaran terdahulu, sila layari- http://www.mytnb.com.my atau hubungi Hotline TNB 1 300 88 5454
Untuk gangguan bekalan atau kerosakan lampu jalan TNB sila hubungi melalui telefon/SMS: 15454

Untuk pertanyaan, sila hubungi:

TNB PASIR MAS
JLN MASJID LAMA,PASIR MAS
17000 PASIR MAS
KELANTAN
Tel : 09-7909029
Fax : 09-7908120