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SPOSOL: 5 IN 1 SMART PORTABLE SOLAR LIGHT

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ABSTRACT

Smart Portable Solar Light is a project based on a circuit obtained through the internet connection. A few modifications have been done to the original circuit; original circuit uses eight LEDs while this project only uses one main LED. The main source of this system is harvest form the sun. The sun's radiation is converted to electrical energy that is supplied to a battery, which acts as a power storage for the system. Another set of batteries is used as the structure of the lamp is design to be portable.

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At the detachable section of the lamp, there is a power point that can be used as a charger for small voltage devices such as mp3s not exceeding 5V. Therefore, this project is suitable to be used as a stand lamp as well as torchlight.

Keywords: stand lamp; garden light; emergency light; torchlight; power source.

1. INTRODUCTION

Nowadays, we are faced with the issue of not having enough energy to support the development of our country. Natural resources of our country including petroleum, natural gas and fossil fuels are non-renewable energy source. These fossil fuels pollute more and once extracted from the earth, they become limited.

This is why more and more developed countries such as Japan and the United States turn to renewable energy. They include solar [1-3], wind, water, biomass [29-30] and many more. In Malaysia, we have abundant sunshine because our climate is hot and humid. Therefore, solar energy is the most suitable energy source to produce electricity.

There are many studies have been explored on portable solar including inventions that have been patterned. For example, portable solar power system [4], portable solar generator [5], portable solar module cart [6], portable solar light tower [7], portable solar energy system [8], portable solar power supply trailer with a security containment area and multiple power interfaces [9], portable solar energy supplying device [10], portable solar charged operated lamp having orientation switch for selectively energizing lamp based upon its physical orientation [11], portable solar power supply system and its applying device [12], portable solar panel with attachment points [13], portable solar-powered cd player and electrical generator [14], portable solar and wind-powered energy generating system [15], portable solar generator [16], portable solar/non-solar cooker [17], portable solar power source [18-19], portable solar electrical generator and water filtration and desalination system [20], portable solar water heater [21], solar powered portable light apparatus [22], portable solar-heating system having an inflatable solar collector [23], portable solar charger with controlled charging current for mobile phone devices [24], solar powered portable water purifier [25], portable solar charging apparatus [26], portable solar systems using a step-up power converter with a fast-speed MPPT

and a parallel-configured solar panel to address rapidly changing illumination [27], solar powered portable food container [28], etc.

1.1. Problem Statement

The electricity tariff has risen in the last year due to the decreasing amount of fossil fuels in the country. Fossil fuels that are usually used are petroleum, natural gases and coal. Power stations burn these fossil fuels to generate electricity. It is bad for the environment because the burning of the fossil fuels produces carbon dioxide, which is a greenhouse gas. This gas will lead to thinning of the ozone layer and global warming. The problem right now is how to reduce global warming.

To overcome this problem, renewable energy sources should be used. Renewable energy is abundant in Malaysia. There are solar, wind, hydroelectric and many more. If renewable energy is used on a large scale, not only there will be a drastic change in the earth's atmosphere, the production of carbon dioxide can also be reduced. Although global warming cannot be reversed, it can be controlled if renewable energy is used.

1.2. Objectives

1.2.1. Encouragement to the Usage of Renewable Energy

Today, fossil fuels are becoming more and more limited. The electricity tariff has also risen due to this problem. To overcome this situation, renewable energy has been the prime choice for people who are conscious about the environment as well as their pockets. Solar energy is the leading renewable energy source because it is abundant in Malaysia. It has higher reliability when compared to other resources because of the hot and humid climate all year round.

1.2.2. Modification on Device to Be Multifunctional

Gadgets nowadays have many function rolled up into one. The printer for example has evolved from being a just a printer to being a multifunctional device. It is now a printer, scanner, copier and a fax machine in one. It is suggested that an ordinary, boring tool to be modified into something that has more than one function.

1.2.3. Keeping Intruders Away from the House

The newest home security system right now is equipped with the latest technology. Most of

the home security system uses sensors such as infrared sensor and passive infrared (PIR) sensor. They are implemented at the gate or outside the house. But, what happens when the intruder is already inside the compound? This project solves the problem by using a high sensitive intruder alarm to catch even the slightest shadow. It can be placed anywhere the owner does not want anyone to trespass.

1.2.4. Implementation the Uses of Sensors in Daily Life

There are many types of sensors in the market. There are sensors for sound, motion, light and many more. The invention of sensor is to make our lives easier by making the switch old-fashioned. For example, motion sensor such as PIR is used to turn on lights automatically when a person enters a room. In this project, the sensor that is put into practice is a light dependent resistor (LDR). If it detects darkness, the light will light up involuntarily.

1.2.5. Functionality of Project

The original circuit of this project is shown it the figure below. In this project, the circuit is modified and divided into two circuits; charge controller circuit and the portable circuit. The main scope of this project focuses on the charge controller.

The charge controller consists of the IC LM2941CT, potentiometer, a network of resistors and capacitors and a Schottky diode. A charge controller or charge regulator is similar to the voltage regulator. It regulates the voltage and current coming from the solar panels going to the battery. The panel used put out about 16 to 20 volts. So, if there is no regulation, the batteries will be damaged from overcharging. Most batteries need around 14 to 14.5 volts to get fully charged. The 1N5817 Schottky diode prevents the battery from discharging through the voltage regulator during the night. It also protects the circuitry against reverse battery connection.

The other main scope is the multifunctional of this project. The Smart Portable Solar Light has many functions. Other than being a stand lamp, it is also can be used as a garden light, emergency light, torchlight and a power source. The source can supply power to a low-power DC appliance such as MP3s and mobile phones. The torchlight can be detached from the lamp post and can be brought anywhere desired.

Other than that, the lamp post acts as an intruder alarm. The alarm makes use of a light

dependent resistor (LDR) as a shadow detector to sound an alarm. The solar lamp can be positioned anywhere desired by the owner that they do not anyone to intrude. For example, the lamp can be placed at the front door and if there is an intruder, they will be caught off guard because the sensor is disguised as an ordinary lamp.

Lastly, there is another LDR sensor that detects darkness in the project. This project can also be set as an emergency light. It detects darkness and will turn on a LED light located at the stand. For instance, when the owner is out of the house and forgets to turn on the light inside the house, the LED will light up during the night.

2. METHODOLODY

2.1. Circuit Implementation

This project divided full circuit into two parts. It is solar circuit and LED circuit. This is because based on the prototype that will be produced. LED circuit place in the portable lighting and the solar circuit placed at the base or in the stand lamp.

2.2. Circuit Operation

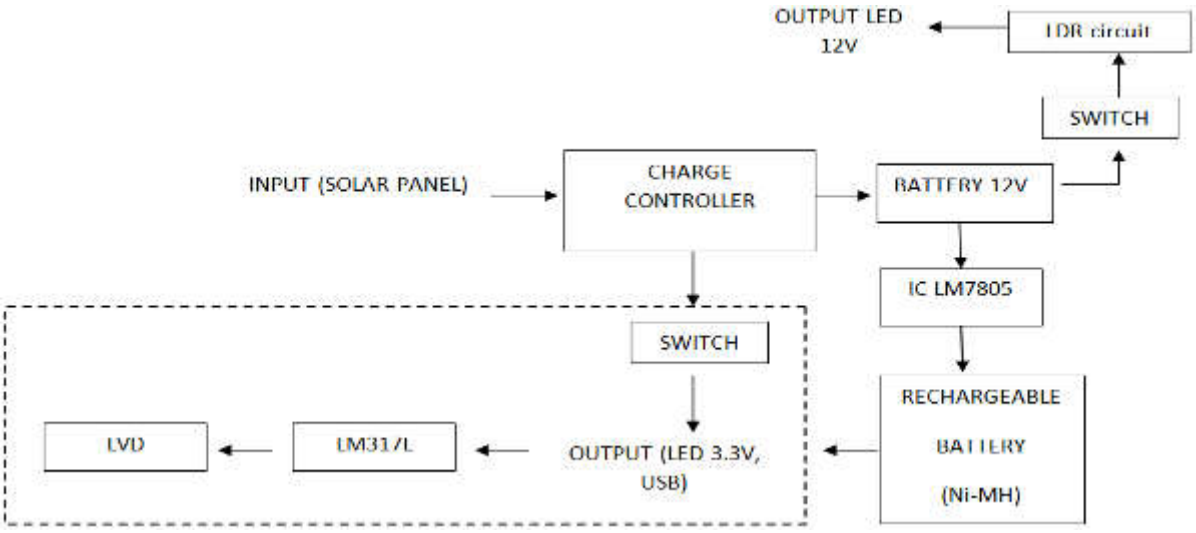

Fig.1. Circuit operation of smart portable solar light

Based on the block diagram, the input which is the solar panel passes voltage to the charge controller. The charge controller consists of an LM2941CT low voltage dropout and a 1N5817 Schottky diode. The IC passes the solar power to the rechargeable battery until it is full. After that, it limits the charge current to maintain the charge voltage. The Schottky diode on the other hand prevents the battery from discharging through the charge controller at night.

The charge controller is then connected to the LED circuitry. In the LED circuitry, there is a switch, an IC and a sub-circuit which connects to the load which is an LED and a USB port.

The LED circuitry consist of a switch, a low voltage disconnects circuit (LVD) and an LM317L. The switch selects the mode of operation. When the switch is turned on, the LED will light up as well as there is current through the 2-pin plug and USB port. When the switch is turned off, LED will turn off and there will be no current passing through the USB port.

The LVD consist of a Zener diode and a 2N3904 transistor. This LVD will cause the LED power to drop as the battery is approaching empty much like a laptop battery. This will prevent the battery from totally discharged and improves the lifespan of the battery. The LM317L IC acts as current regulator for the output load and is connected in series with it. It also provides overload protection for the load.

2.3. Additional Circuit

2.3.1. Emergency LED

Emergency LED is automatically switches ON when the night falls and turns OFF when the sun rises. In fact, this circuit for implementing any type of automatic night light.

The circuit uses an LDR to sense the light. When there is light, the resistance of LDR will be low. So, the voltage drop across POT R2 will be high. This keeps the transistor Q1 ON. The collector of Q 1(BC107) is coupled to base of Q2 (SL100). So, Q2 will be OFF and so do the relay. The bulb will remain OFF.

When night falls, the resistance of LDR increases to make the voltage across the POT R2 to decrease below 0.6V. This makes transistor Q1 OFF, which in turn makes Q2 ON. The relay will be energized and the bulb will glow.

2.3.2. Emergency Alarm

Emergency alarm is the circuit of an ultra-sensitive intruder alarm. The shadow of an intruder passing few meters nearby the circuit is enough to trigger the alarm. Here, IC2 uA 741 is wired as a sensitive comparator whose set point is set by R6 and R7. The voltage divides by LDR and R9 is given at non inverting pin of IC2. At standby mode, these two voltages are set equal by adjusting R9. Now, the output (pin6) of comparator will be high. Transistor Q1 will be off. The voltage at trigger pin of IC1 will be positive and there will be no alarm. When

there is an intruder near the LDR, the shadow causes its resistance to increase. Now, the voltages at the inputs of comparator will be different and the output of IC2 will be low. It makes Q1 on. This makes a negative going pulse to trigger the IC1, which is wired as a monostable multivibrator. The output of IC1 will be amplified by Q2 (SL 100) to produce alarm.

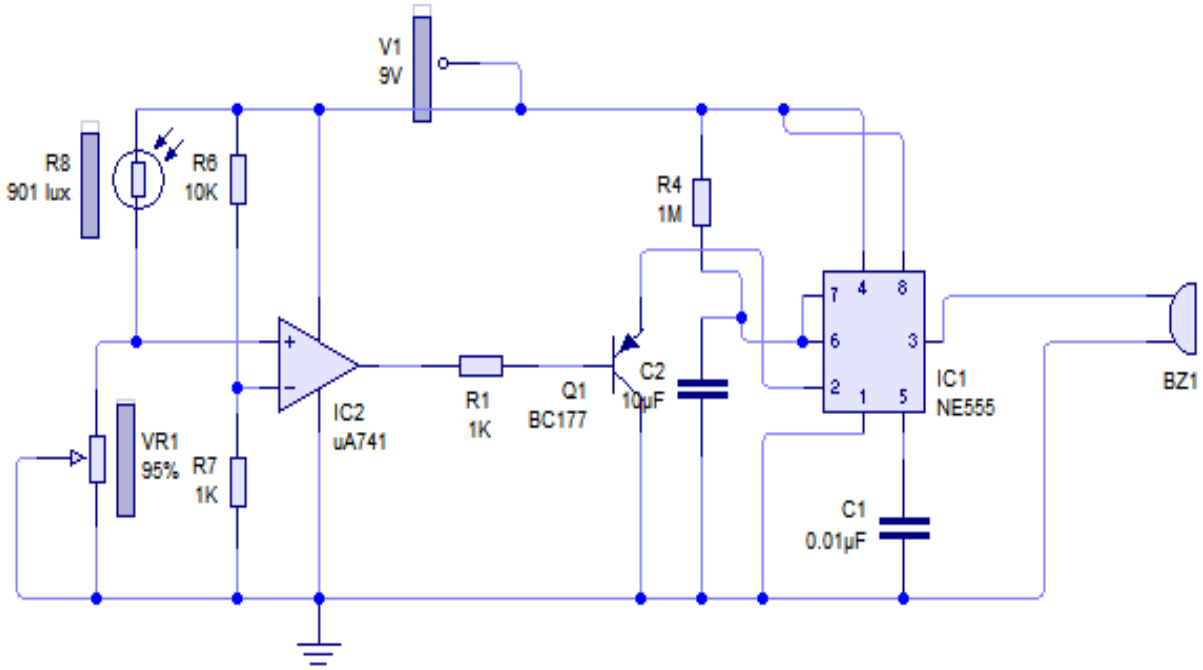

Fig.2. Emergency alarm circuit

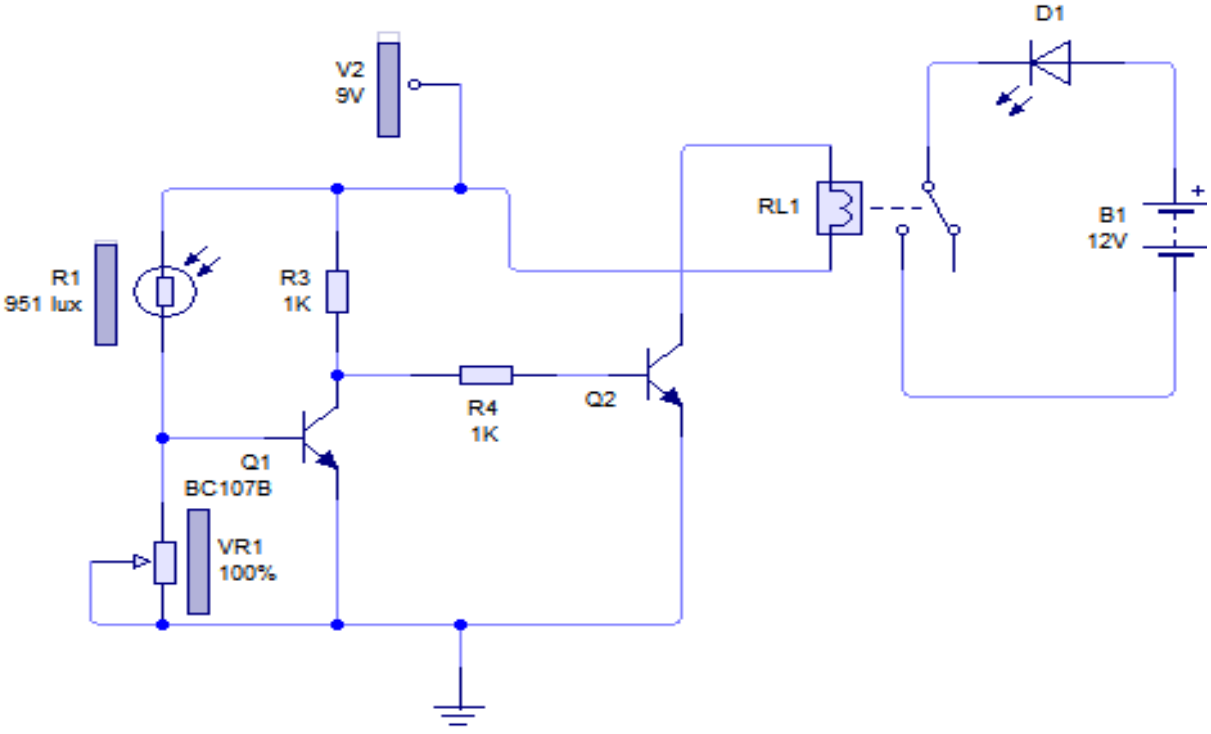

Fig.3. Emergency LED circuit

2.4. Flow Chart Smart Portable Solar Light

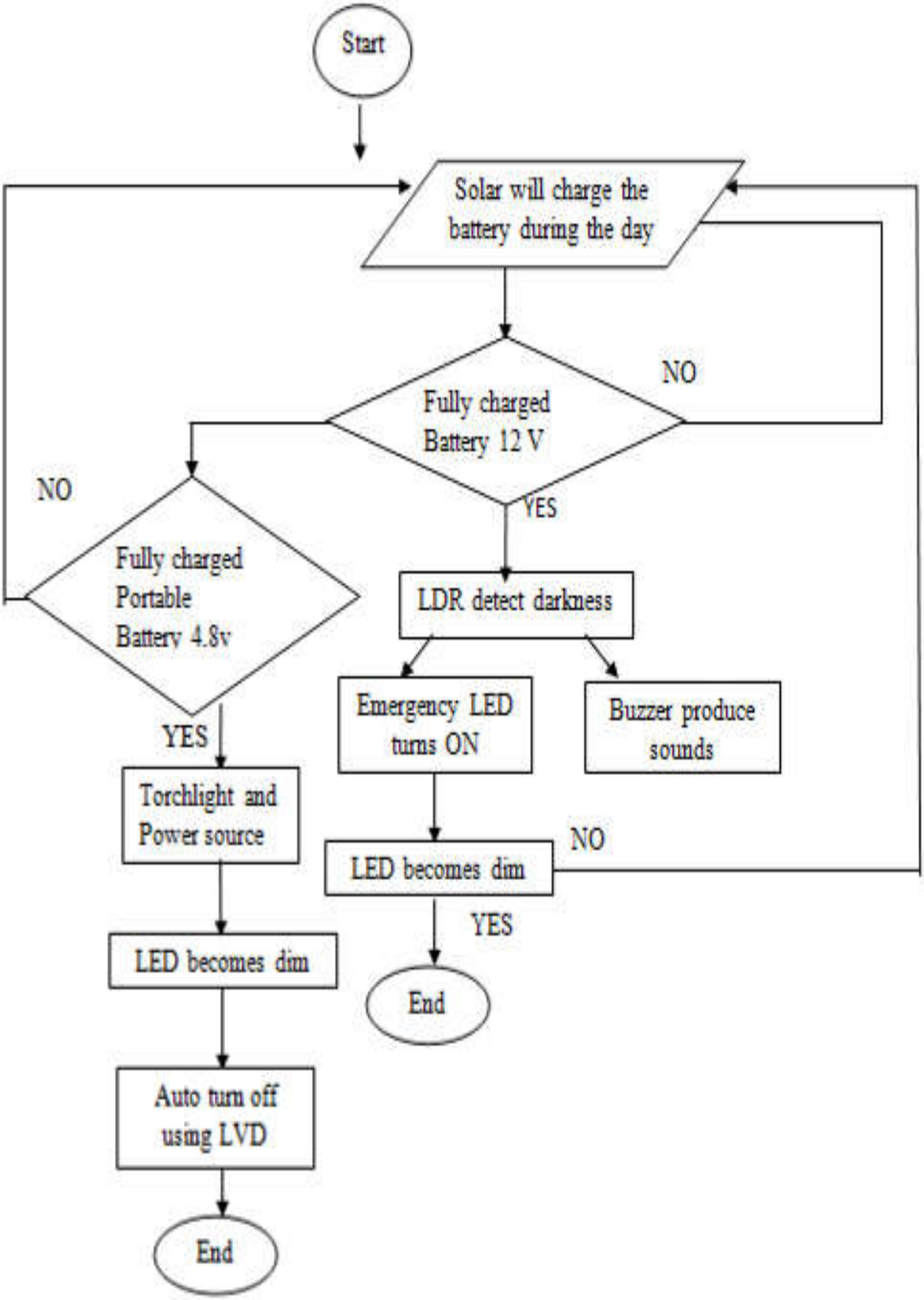

Fig.4. Flow chart of smart portable solar light

3. RESULTS AND DISCUSSION

3.1. Hardware Development

Fig.5. Solar circuit

Fig.6. Portable circuit

Fig.7. Emergency LED

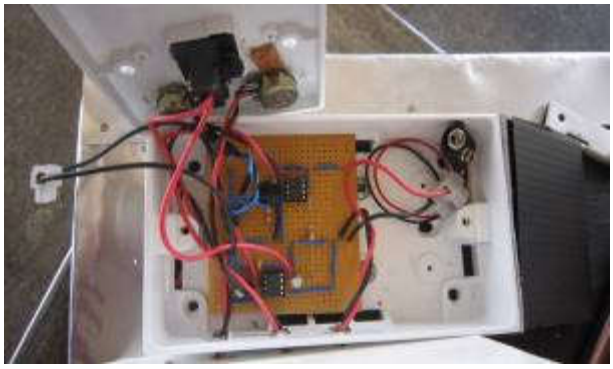

Fig.8. Emergency alarm

3.2. Troubleshooting on PCB

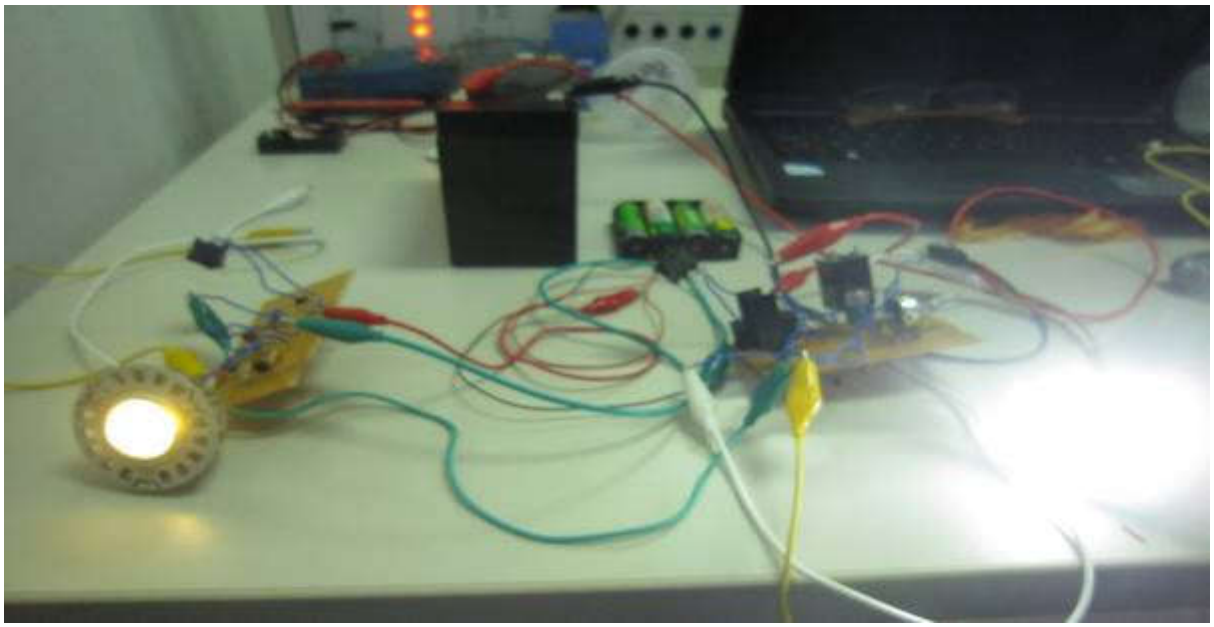

Fig.9. Both 12V LED and 1W LED light up

3.3. Prototype

Fig.10. Prototype

Fig.11. Exhibition day

Fig.12. Turn OFF when the light detected

Fig.13. Automatic ON when no light detected

Fig.14. Solar panel

Fig.15. 12V MR16 LED

Fig.16. Emergency alarm

Fig.17. LDR sensor

Fig.18. Front view

Fig.19. Side view

Fig.20. 12V battery box

Fig.21. Solar circuit and emergency alarm circuit box

Fig.22. Emergency alarm circuit box

Fig.23. Portable light

3.4. Results between Simulation and Troubleshoot on PCB

Table 1. Results between simulation and troubleshooting on PCB

Component	Pin IN		Pin OUT	
	Simulation	Troubleshooting	Simulation	Troubleshooting
Solar Circuit				
Solar panel	-	-	18.00V	18.00V
LM2914CT				
- With 12V battery				
Connected	18.00V	18.05V	11.92V	11.77V
- Without 12V battery				
Connected	18.00V	18.00V	9.76μV	11.76V
- Potentiometer				
Highest (right)	18.00V	18.00V	18.00V	13.11V
Lowest (left)	12.00V	13.19V	12.00V	10.00V
Portable Circuit				
LM7805	11.92V	12.14V	272.7mV	5.00V
White LED	-	-	3.42V	3.82V
USB	-	-	3.50V	3.86V
LDR Circuit		**Emergency LED**		**Emergency**
- Potentiometer	-			**Alarm**
Highest		95kΩ (right)	-	5.1kΩ (right)
Lowest		0.1Ω (left)		10Ω (right)

3.2. Discussion

In simulation, the solar panel is replaced with a DC supply of 12. However, the output voltage measured at the LM2941CT is in mV. The DC supply is then changed to 18V, which is the actual rated output of the solar panel. When measured, the output of the IC is 12V.

When troubleshooting with the 18V, 10W polycrystalline solar panel, a whole 6 hours is needed to fully recharge the 12V battery. To overcome the overcharging of the battery, a Schottky diode is used to cutoff the charge and disallows current to flow in reverse direction.

In simulation, adjusting the 5k potentiometer will not affect the LM2941CT whatsoever. Conversely, when troubleshooting, the potentiometer controls [31-32] the range of input and output of the IC. Fuse is used as a protection in this circuit. It protects the main circuit from overloading voltage or current. A resistor is added before each load device to protect them from blowing. A suitable resistance is chosen based on the voltage drop required by the load.

When troubleshooting the combined circuits, it is found that the LM317L is not compatible with the circuit. The IC did not drop the voltage from 12V to the voltage wanted by the portable circuit to recharge the battery. When voltage is measured at the output pin of the IC, it gives the same value as at the input pin which is 12.67V. The IC voltage regulator is replaced with another IC voltage regulator; LM7805. After replacing the IC, the voltage obtained is equivalent to the voltage required to recharge the battery (5V). Besides that, the LM7805 is more suitable as it drops the voltage at exactly 5V whereas LM317L does not drop the voltage at all

In simulation, there is no problem arise in the portable circuit. When tested on the PCB, two batteries used (1.2V, 11W Ni-MH each) are not sufficient to light up the 3.3V, 1W LED. Based on the observations, two more batteries are added so that the total voltage is 4.8V and enough to light up the LED.

At the USB port, only two pins are connected, Vbus (+5v) and pin GND (ground). If only two pins are connected, the USB port will only charge no-data devices. To improve the function of the USB port, the other 2 pin; D-(data-) and pin D+ (data +) is connected. Therefore, we use USB with 4 pin in our circuit.

4. CONCLUSION

By using this project, the reliance on fossil fuels to generate electricity will decrease. Renewable energy specifically solar power is the best choice because there is abundant sunshine in Malaysia. The project applies solar power as the primary source of energy. It charges the 12V battery a set of portable batteries at the head of the lamp post. Even if the batteries are excluded, the solar can be directly connected to the 12V LED light and the system can be used as usual.

A boring lamp post can be modified to be a multipurpose tool. There is a torchlight that can be detached from the head of the lamp post and can be used as a power source and light source. At the lamp post, there is a darkness sensor that automatically turns on a LED light when it gets dark. It also has a highly sensitive intruder alarm that senses the slightest shadow and triggers an alarm.

The alarm consists of an LDR that senses the slightest shadow of an intruder. Normally, for a home security system, a motion sensor is used. A timer is also used to set how long the buzzer will sound. The sensitivity of the LDR can be set at the potentiometer according to the light intensity of the lamp post surroundings. Another potentiometer sets the time of the buzzer will go off. The sensor is hidden in the lamp post so if an intruder is present, they will never suspect an ordinary lamp post to have a sensor and an alarm.

The sensor used in the automatic light senses darkness and can be applied during blackout situations. If the owner does not want the light to automatically turn on, there is also a switch to disable that feature. The intruder alarm also has a switch which the owner can turn off the feature when they do not want any sound or when they are inside the house.

5. FUTURE RECOMMENDATIONS

For the future recommendation of this project, another renewable energy can apply such as wind or water energy to backup source of this project. Besides that, renewable energy is abundant in Malaysia. There are solar, wind, hydroelectric and many more. If renewable energy is used on a large scale, not only there will be a drastic change in the earth's atmosphere but also can reduce global warming. Improvement can add in this project such as the LDR sensor can be change to another sensor that is exact to motion such as PIR or IR sensor. These sensors have more accurate distance can detect object in motion. To make this project more multi-function, another power source such as 2 or 3 pin can add at the stand of this project. Besides that, the voltage of battery needs increase to support the output.

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