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# Solar Battery Charging Controller System on Marine Vessels

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**ABSTRACT**

We depend on emergency equipment onboard ships, especially during emergency or uncontrollable situations. Batteries are required to operate most emergency equipment onboard marine vessels, and power distribution systems are used to distribute power to the system. ICE engines are used for the generation of power. This source of power is used to brighten up the whole vessel day and night, and at the same time, these power sources are stepped down to charge those batteries. Due to this, more fuel is required to charge the batteries to maintain reliability of the batteries. It seems the vessel will be sailing out to an open sea with very minimal interferences, and solar energy is in abundance; why not use this reliable source instead. Hence, we have come up with this solar battery charging idea. This system helps to utilize solar power and is able to convert it as a charging source to the batteries. This project has many benefits where fuel consumption can be reduced, and dependency on power sources via generators can be reduced as well.

**ARTICLE INFO**

*Keywords:*
LED Light
Emitting Diode
MCU Microcontrollers
PIC Peripheral
Interface Controller
UMS Unattended
Machinery Space
UPS
Uninterruptible Power
Supply
ICE
Internal Combustion
Engine

## 1.0 INTRODUCTION

Onboard ships, self-managing programmed systems are used to run the general basic systems. Uninterruptible Power Supply (UPS) systems ensure the consistency and safety of normal operation onboard. However, all this emergency equipment that aids emergencies depends on ship electrical sources as the source of energy. It consumes tons of fuel for those generators to continuously generate a huge amount of electrical power to support the battery charging. So, we came up with an alternate idea which is “solar battery charging”, where usage of MCU, PIC and LEDs helps support and reduce work pressure on our generators (Marufa, 2012). This system always ensures safe and secure working conditions and ensures reduced pollution at sea, which helps maintain equilibrium habitability at sea.

## 2.0 LITERATURE REVIEW

Marufa F. (2012). Designing Smart Charge Controller for the Solar Battery Charging Station, BAAC University, Dhaka, Bangladesh. As stated in the reference above the work presented was carried out on microcontroller for controlling the overcharging and discharging of a battery. Battery Circuit regulates solar power to charge battery to max level. Further software can be used to monitor the output voltage, current, temperature and solar panel charging status.

Mohd Tariq, S. Bhardwaj and Mohd Rashid. (2013). Effective Battery Charging System by Solar Energy Using C Programming and Microcontroller. American Journal of Electrical Power and Energy Systems, p. 3. In their study, stated that many countries are up to renewable energy sources in terms of saving fuel and environmental concern. This solar panel is programmed to be used as renewable source of energy at the same time does not pollute the environment. This system also able to support and supply power during night too, where is conserves the energy during day.

W. Thounaojam, V. Ebenezer and A. Balekundri. (2014) Design and Development of Microcontroller Based Solar. International Journal of Emerging Technology and Advanced Engineering, p. 4. This explains a research on designing and developing unique microcontroller, where initially they had an issue where there is power loss when solar is connected directly to a battery without proper matching of their impedances. So, unique charge controller designed to overcome the power loss and to provide stable energy conversion and conservation.

In a long run, these references are taken into consideration as a study and research as a start for our project. As these references are based on the microcontroller designing and programming, where they came up with new technology programmed to overcome the cons during the application of their theory into reality. Furthermore, as these industrial trials can be modified and redesigned to fit in our marine purposes. As we all getting to accept the new norm, where this project of ours will be the future of Marine Industries. They are renewable, efficient and convenient in preserving and conserving the solar energy without polluting the environment and the eco-system within it.

### 2.1 INITIAL SYSTEM

Initially, the battery charger is supported by main generators onboard. While the main generators supply those running loads, it also supports the emergency systems such as battery charging of the Emergency Generator (Ashiquzzaman et.al, 2011), emergency lighting panels, and emergency navigational equipment. All these systems must be prepared as we all know anything can happen at any time. So, this emergency equipment must be in good working order, and a sufficient power source is needed to maintain the integrity of the system.

## 2.2 ADVANCED SMART SYSTEM

Solar battery charger system is introduced as an alternate and innovative system to support and sustain emergency battery charging systems for emergency equipment. This smart system is unique in such a way that it detects light sources (solar energy) and converts them into electrical energy to charge batteries. So, during the daytime, when solar power is present, it will be detected by the system, and auto solar charging occurs. Capacitors store the additional energy once an adequate amount of solar power fully charges the batteries. At the same time, the ship's generator power source will be cut off from charging these batteries while solar charging occurs (Kondracki, 2011). When the system detects no light (night/dark environment), the sensors will automatically detect the environment, and the generator power source will further continue charging batteries as this is a fail-safe system

## 3.0 METHODOLOGY

A Microcontroller will constantly regulate the electric flow for charging or discharging the batteries, and at the same time, inform the end-user via LCD Display Unit. An LDR Unit will be used to simulate the Photoelectric Charging Station, where the light intensity is adjusted by a controllable light source near LDR [4]. Upon receiving enough light intensity to let current flow thru LDR, the relay in Photoelectric Station then energizes, causing the signal voltage to flow to MCU. This will let the current flow into the circuit of the Battery Charging Station.

In the Battery charging station, a voltage regulator is used to maintain a steady constant voltage according to the voltage requirement of the system (Tariq et.al, 2013). A bipolar junction transistor, in conjunction with a Zener diode and normal diode, was utilized to ensure a unidirectional flow of current into the battery. An MCU is utilized to ensure operation of offload and onload of battery is achieved via input from the Photoelectric signal outlet, which indicates whether there is a current supply from Photoelectric Station or vice versa. The MCU controls the flow of the circuit by allowing current flow or blocking the current flow in respect of its set condition. There are two LED indications available in the circuit that indicate the condition of the battery, whether it is in the onload condition or offload condition [5]. There are warning systems installed together, including the buzzer that will be activated when the offload condition occurs. This warning could be some combinations of LEDs and buzzers. Such LEDs, which serve display purposes, could be installed on the panel boards.

In the LCD Display Unit Circuit, a signal is received from the first MCU to indicate the condition of the circuit. Upon receiving the signal, the installed information will display accordingly. This system which is a combination of LEDs, buzzers, and LCD Display units, serves as both an information and warnings system.

### 3.1 COMPONENT

The components of the system consist of (1) PIC16F84A. This Microcontroller comes with only 18-pins. Three units were utilized where 1 is Master, and the remaining unit is Slave, (2) LDR, this unit will reduce resistance when there is light supplied to the surface, (3) LM317T Voltage Regulator used to ensure steady current supply in the circuit, (4) Bipolar Junction Transistor is used to ensure unidirectional flow of current in a circuit, (5) Zener Diode is used to ensure unidirectional flow of current in the circuit, (6) Diode is used to ensure unidirectional current flow in a circuit is achieved, (7) Battery is used to simulate Lead Acid Batteries, (8) Voltage Indicator is used to read the charging voltage of the battery, (9) Light Emitting Diodes (LEDs) to turn as a visual response, (10) Buzzer which function as hearing response aids, Liquid Crystal Display (LCD) as information display for end-user, (11) Relays which will be used to control flow circuit in accordance with the input. (12) Voltage Meter used to read voltage reading across the battery charging circuit. Figure 1 illustrates the schematic diagram of the system design.

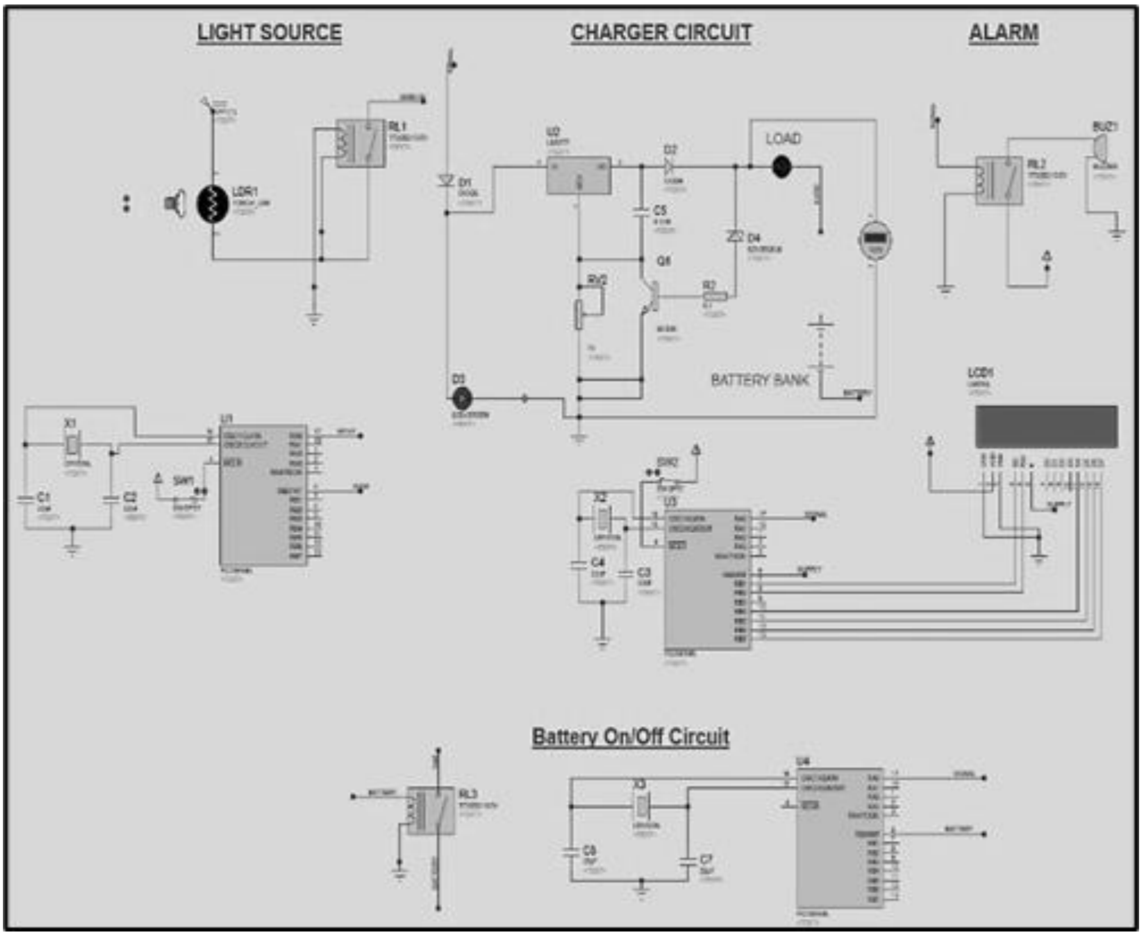



Figure 1 : Simplified Schematic Diagram

### 3.2 OPERATIONS

The operation concept is described below:

Charging (Offload Condition)

- The light source is near the LDR during charging conditions, causing LDR resistance to drop.
- This will cause the current supply to flow into Relay R1.
- Upon energizing R1, signal current flows into MCU 1, which is the Master MCU of Circuit.
- Master MCU simultaneously gives two signals and allows current to pass through the battery charging circuit [6].
- One signal goes to the LCD display unit, which projects “BATTERY OFFLOAD, CHARGING ON” on the display unit.

- Another signal goes to the Onload/Offload Mechanism, where it controls a relay to simulate a breaker/contactor for the circuit. This will give indicators (LED, Buzzer, LCD) whether the system (Load/Consumer) is supplied by the battery or from the main source.
- In the Battery Charging Circuit, the current is allowed to flow from Photoelectric Station into Voltage Regulator.
- The current will flow into a Bipolar Junction Transistor and through the Zener Diode, and it will then pass into Load and the battery itself.
- Upon controlling the distance of light, thus controlling the resistance of the circuit, it can note that the voltage of the battery will start to increase and can be said inversely proportionally to the distance of the light source to the LDR.
- Reading of charging voltage can be noted from the Voltage Meter in the Charging circuit.
- In this condition, Buzzer will not be energized.

Discharging (Onload Condition)

- During discharging conditions, the light source is far from the LDR, causing resistance of the LDR to increase.
- This will cause no or insufficient current supply to flow into Relay R1.
- Upon de-energizing R1, no signal current flows into MCU 1, which is the Master MCU of Circuit.
- Master MCU then simultaneously cut off two signals to MCU 2 & MCU 3 and no current to pass through Voltage Regulator.
- On the LCD Display unit MCU, upon no signal received from MCU 1, will project "BATTERY ONLOAD, CHARGING OFF" on the display unit.
- On the Onload/Offload Mechanism MCU, upon no signal given by MCU 1, the relay will de-energize, causing the battery circuit to complete the Load. This will indicate that the current flows from the Battery into the Load [7].
- An indication of LED will be light up, and simultaneously buzzer will energize for this condition.
- In the Voltage meter, it can also be noted that there will be no voltage as current now is flowing into the Load itself only.

Table 1 shows the logic of the operations.

| INPUT | OUTPUT | | | |
|---|---|---|---|---|
| RA0 (MCU 1) | OUTPUT TO CHARGER CIRCUIT & ALARM (RB0 MCU 1) | INPUT AND OUTPUT LCD DISPLAY (RA0 & RB0, MCU 2) | INPUT CHARGER CIRCUIT (RA0 MCU3) | OUTPUT CHARGER CIRCUIT (RA1 MCU3) |
| 1 | 1 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 |

## 3.3 MICROCONTROLLERS

PIC16F84A (Figure 2) is a microcontroller produced by Microchip known as PIC. PIC stands for Peripheral Interface Microcontroller, and it was developed by the General Instruments Microcontrollers. It is designed to execute various activities and is controlled by software. There are many different microcontrollers, some of which have limited memory. These microcontrollers are nearly cost-effective, practical, and easy to find. It includes a superior performance RISC CPU with the highest operating frequency of 20MHz.

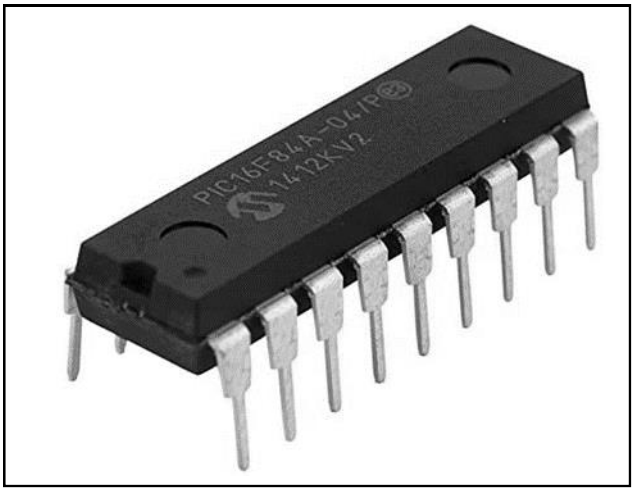



Figure 2: Micro Controller Unit (MCU) PIC16F84A

Nevertheless, it can be used on a smaller frequency to conserve power. It is an 8-bit microcontroller. Thus, the range of the data bus is 8 bits. It has 1024 words of program memory. If you are working on straightforward functions, then 1024 words of program memory are adequate, where PIC16F84A is commonly utilized [9]. The data memory (RAM) has 68 bytes, and the data EEPROM is 64 bytes. There are also 13 I/O pins that the user sets on a pin-to-pin source. Some pins are multiplexed along with other gadget tasks. These tasks consist of external interrupt, change on PORTB interrupt and Timer 0 clock feedback [10]. Three PIC16F84A is used for this system. The first U1 MCU is used as the brain of the system, and its main purpose is to send a signal to the circuit to charge the battery when the photocell has the right amount of light. U3 will receive the signal and power up the LCD screen for the purpose of monitoring the circuit status. U4 is used for onload and offload the battery. PIC is the integrated circuit regularly used in the exterior controlling devices and lighten the load from the main CPU in the system. If we compare the system with a human being, the main CPU acts as a brain, and the PIC is like our autonomic nervous system. As a result, it is recommended that an 8-bit PIC16F84A microcontroller be used as the system's core controller.

## 3.4 SOFTWARE

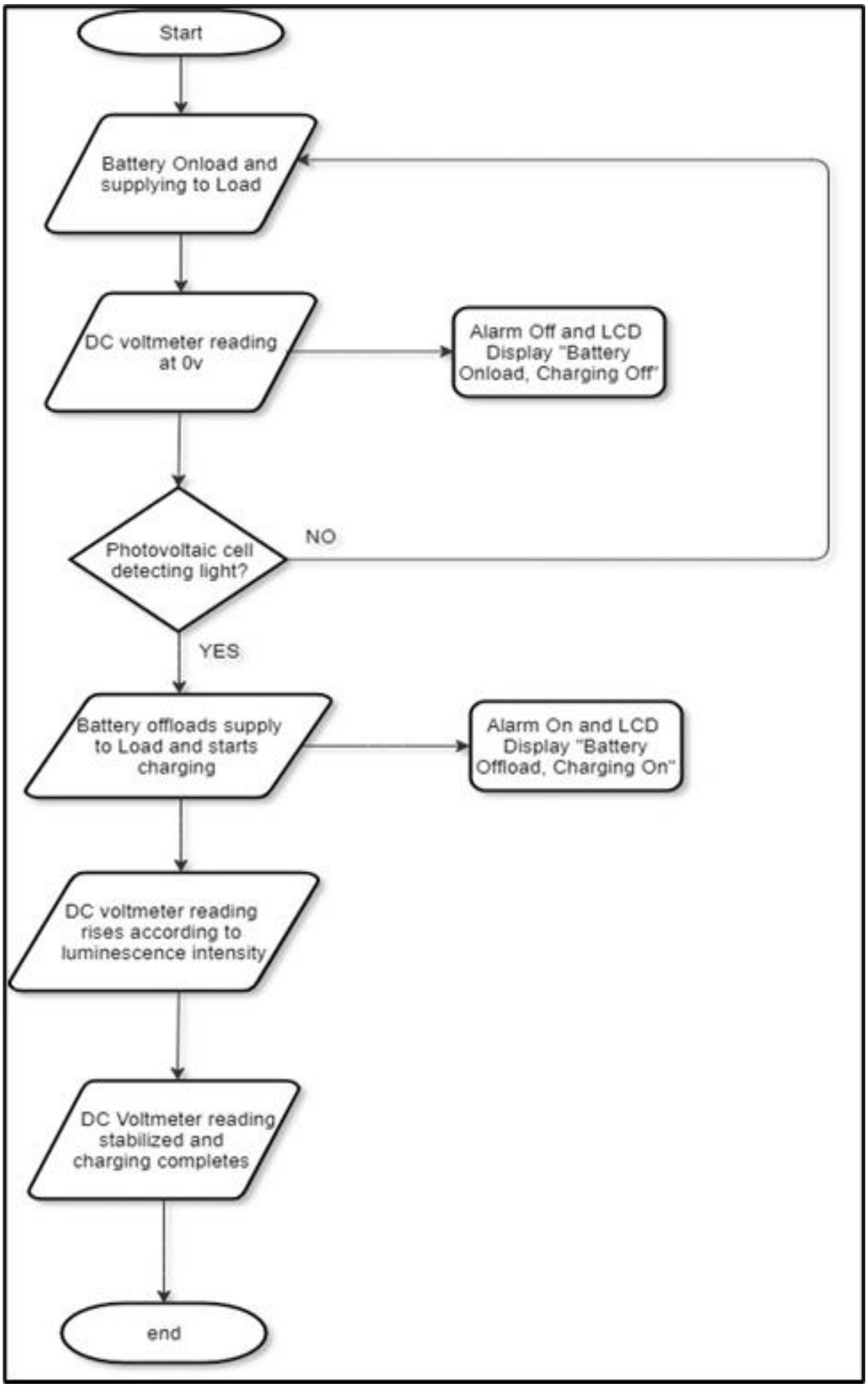
The "C compiler for the PIC MCU" is applied for writing, editing, compiling, and programming the codes for the microcontroller. This compiler enables the microcontroller to be personalized in high-level programming languages. The condition of the components will be determined by the algorithm of the codes, which will actuate the microcontroller's input-output ports while considering the specific duties. The basic idea of the system is to harness the sun’s rays to charge the battery and, where possible, not use the electricity from the ship’s system.

## 3.5 PROGRAMMING DESCRIPTION

The program which managed to control the entire system is rooted in the PIC16F84A microcontroller's C language. All the codes have been compiled and checked to make use of the CCS compilers.

## 3.6 SYSTEM FLOW

The system works when initially the battery bank will charge the load. When the photocell receives enough light, it will send a signal to the microcontroller U1, which will send a signal to U3 and U4 microcontroller, and the buzzer is also the main circuit. U3 microcontroller will power up LCD to inform the person in charge of the condition of the battery if it is onload or offload. The U4 microcontroller will mainly determine the condition of the circuit if it is battery-powered or solar-powered. Flowchart 1 shows basically how the system works.




Flowchart 1: Flow Chart of The System

## 3.7 CIRCUIT

The circuit has five main elements: The Photoelectric Station, the Battery Charging Station, the Onload/Offload Mechanism, the LCD Display Station, and the Alarms station. All these modules are integrated into the Master/Slave MCU, respectively.

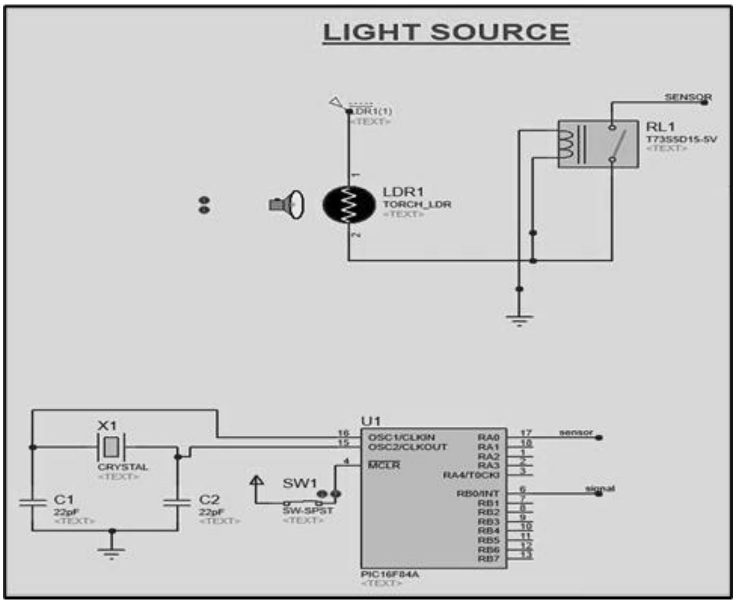



Figure 3: Photoelectric Station

As in Figure 3, it can be noticed that there is a controllable distance between the light source and LDR. This is used to simulate if there is charging available from Photoelectric Cells to the batteries. The relay will energize or de-energize accordingly with the distance between the light source and the LDR.

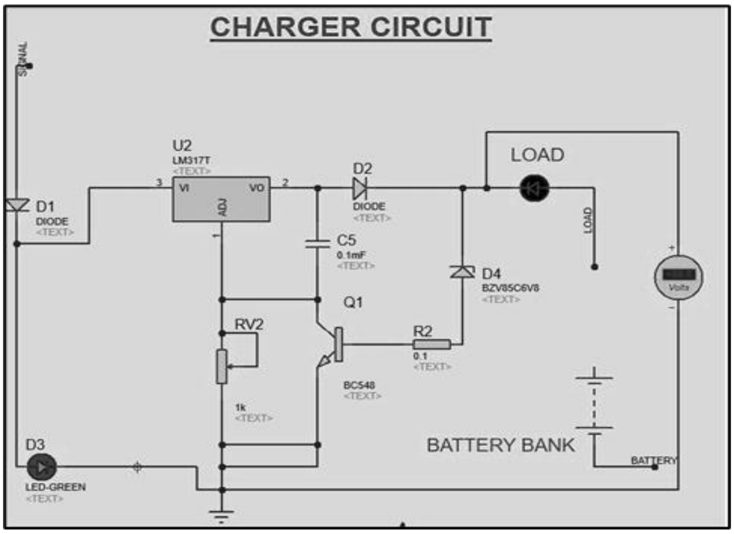



Figure 4: Battery Charging Station

The battery charging station will receive a signal from MCU 1 to allow current flow to Voltage Regulator, Transistor and Zener Diode. The current will flow to load and charge the battery itself upon completing the circuit. The charging voltage may be read from Voltage Meter

(Amathalai et.al, n.d) One Green LED will light up in this condition, indicating ongoing charging and the buzzer will not be energized during this condition.

During offload condition, no current flow through transistor and diode. Thus, the battery supplies current to the Load, the Red LED lights up, and Buzzer sounds.

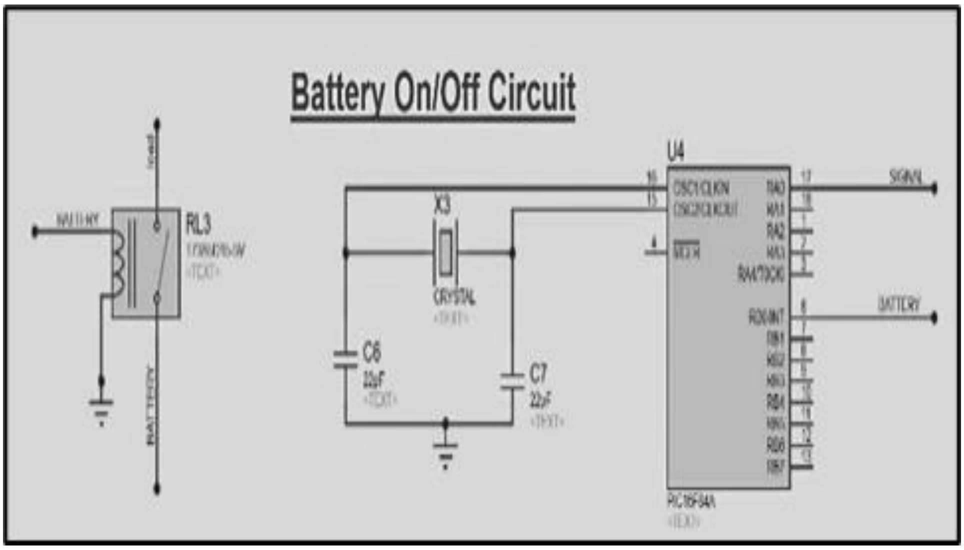



Figure 5: Onload/Offload Mechanism

The Onload/Offload Mechanism will operate accordingly by the signal from MCU 3 (U4), where during onload, the relay will close, and during offload, the relay will open.

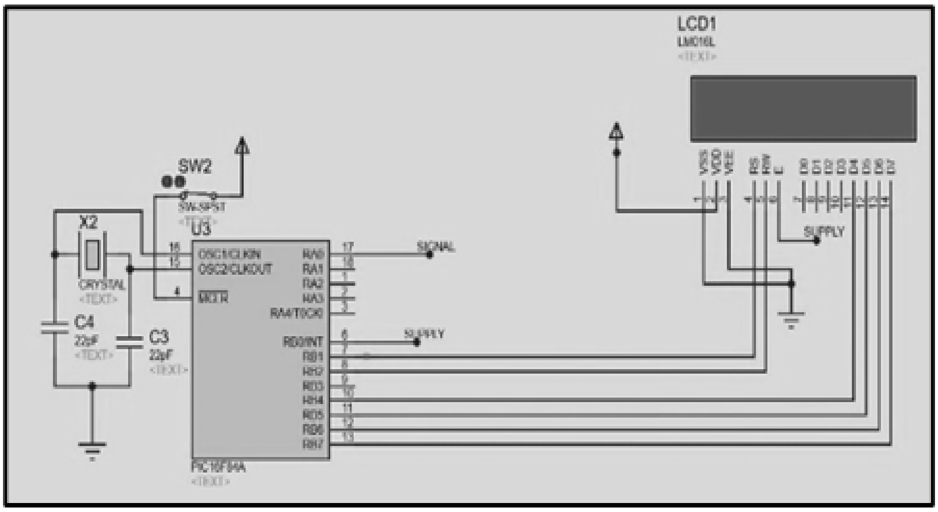



Figure 6: LCD Display Station

The LCD Display station MCU (U3) is programmed to indicate the system is currently in Onload or Offload Condition with respect to the signal given by MCU 1.

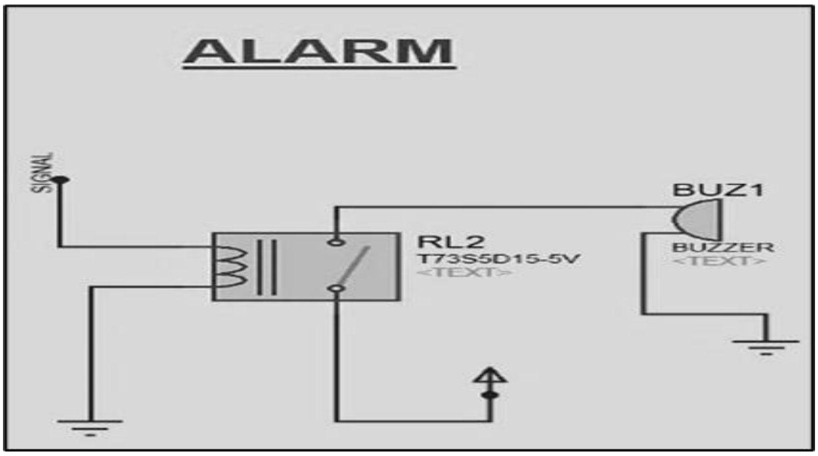



Figure 7: Alarm System

The alarms system will only be triggered under onload conditions, where the battery is used to supply into the load. A signal from MCU 2 will energize the relay, and this will cause Buzzer to be energized and sounded.

## 4.0 FINDINGS AND DISCUSSION

The main purpose of this project is to reduce the usage of conventional charging the battery from the main power source which uses fossil fuel and instead use natural power source. In this case we have opted to harness the sun's rays to power up the battery. During early days, solar panels were only 10% efficient, in today's era they are up to 20% efficient which does not reflect a significant percentage, but on the plus side, consumers do not have to pay for sunlight. This initiative only costs the user for an initial construction cost of the solar to have a renewable energy power source. In an article posted by www.propertyguru.com.my dated back to 22 March 2021, in Malaysia, users can sell back the energy created by solar panel back to the electrical energy provider, TNB (Tenaga National Malaysia). In this case, we can reduce and to a certain extend eliminate the usage of fossil fuel created energy source. The initial system cost could be very expensive, but the cost can be justified by the usage of renewable and clean energy source in the long term which will have a positive impact on not only the environment but the future of our planet.

## 5.0 CONCLUSION

As detailed in the article, the suggested system will be extremely useful in various circumstances when the sun is shining on the panel. The proposed efficient charging mechanism may be applied to any vessel. These robust materials used in this project are readily available in the market, thus cost-effective. Eliminating dependence on fossil fuels and limited resources while designing an environmentally friendly, self-sustainable, outdoor energy source is the goal for the solar-powered charging station. Solar technologies and designs are also quickly improving, leading to a more efficient charging station.

To conclude, clean energies, in contrast to traditional energy sources such as coal, gas, oil, and nuclear, which have finite reserves, are as plentiful as the sun from whence they come and adapt to natural cycles, therefore their term "renewables." As a result, they are necessary components of a sustainable energy system that allows for today's growth without jeopardizing future generations.

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