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Automatic Battery Charger

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Abstract : Automatic Battery Charger is designed for **charging 12V sealed lead-acid batteries. The designed device consists Charging unit , Battery Housing Unit (Drawers) with their respective batteries insider the Drawers which can be charged simultaneously. Each Battery Housing Units provided with its driver circuit, transformer and power supply module. Power supply module is designed with thermal analysis & optimization and protection for EMI/EMC issues. Once the battery is connected to the circuit, it then displays battery charging condition. Battery charging level is displayed by LEDS and LCD is used to indicate the keyed input battery voltage and current through keypad 4X4 manually. Battery type and remaining charging time are displayed on screen during charging on LCD display. PIC 18f452 Microcontroller continuously monitors the battery condition and displays it on LCD. Charging stops when battery is fully charged, audio alarm is indicated with a buzzer and finally the ejection of the drawer tray for removal of the charged battery. This is advantageous as it prevents the battery from damage and over charging. In the front panel of charger there are 6 buttons, LCD, keypad and 6 LEDs. Facility of fast charging and slow charging is provided as per the need. Main charger circuit is constant current charging method.**

***Keywords*: Lead Acid Battery, PIC 18f452, L298, LCD, Keypad, DC motor.**

I. INTRODUCTION

Lead acid batteries were first found in the 1748 to be exact by Benjamin Franklin where he first defines the term 'battery' to describe an array of charged glass plates. Lead Acid batteries are known to be one of the oldest types of rechargeable battery and are still widely used. The main application of these batteries is in automotive field, robotics, emergency lighting in case of power failure.

Figure:1 sealed lead acid battery

A. Battery Voltage

There is much confusion about "battery voltage" because a battery has more than one voltage. There are some general voltages ranges for six-cell (12 Volt) lead batteries.

- Open-circuit(quiescent) of full charge: 12.6V to 12.8V
- Open-circuit at full discharge: 11.8V to 12.0V
- Loaded at full discharge: 10.5V

Besides values I mentioned, there is a term called float voltage. Float voltage which refers to the constant voltage that is applied continuously to cell to maintain the cell in a fully charged condition. With a 12V sealed lead-acid battery to float voltage is in the range of 13.5V-13.8V. Another term, nominal voltage is the voltage value written on the battery. These voltage values vary according to shape, size and trademark of the battery.

B. Battery Current

The unit that is used to measure the capacity of the battery is known as Ampere-Hour (Ah). For example, if a battery has 75Ah means it has the capability to discharge 75A for one hour or 1A for 75 hours. Charging current for batteries must be chosen between one over ten (1/10) and one over twenty (1/20) of the battery capacity, but closer to one over ten.

II. Method of Charging the Lead Acid Battery

There are a few methods that are available or known to be able to charge a lead acid battery but in this case, we are focusing the constant current-constant voltage charging method where it uses a voltage based algorithm that is the same with the lithium ion battery charging method too where a usual charge time for a sealed lead acid battery can be up to 16 hours. There is a faster way to charge the battery which is known as the fast battery charging method where it uses a high current pulse that is pumped into the battery at a faster rate with high capacity of current which will cut down on the charging time but at the same time, if it is not under close supervision, it might damage the battery due to its high current pumping into the battery. The constant current-constant voltage charging method will be explained and further discussed in 3 sections which is the constant current charge, constant voltage (topping charge) and the float (trickle charge).

A. Constant Current Charging

This constant current charging is the first phase of the recharging of the batteries where it usually takes up 50% of the charging period. Usually a battery that has just been discharge have a voltage of 11.50V approximately and when it undergoes the charging process, this constant current charging will ensure that the voltage of the battery rises to a voltage that is determined by the characteristics of the battery itself which will be approximately 13V with a relatively uniform current flow charging the battery. This helps to eliminate the imbalances of cells and batteries that are connected in series which is the most appropriate for cyclic operation where a battery is required to obtain a full charge overnight. In this phase, the battery will be charged up to 70% approximately in the range of 4-7 hours and the other 30% is charged using the trickle charging method. The change of phase from the constant current charging to the next phase occurs when the battery reaches its voltage limit. This method is widely used for most battery chargers. The figure below shows the characteristics of the constant current constant voltage charging.

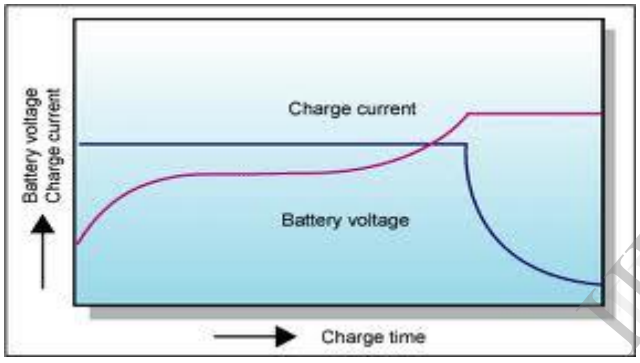

Figure 2 : Constant-Current Constant-Voltage Charging Method

B. Topping (Constant) Charging

This charging takes place when the lead acid battery voltage increases and stays constant at its voltage limit which will be in the range of 12V to 13V. For every standard lead acid battery, the approximate pre-determined battery is 12.6V. Once it reaches its saturated voltage, the current that is applied into the battery will start to decrease where it leads to a full charge condition once it reaches 3% of the rated current. This process is mainly to ensure that the battery cells remains at the same voltage in the battery pack. During the charging and discharging process, each cell in the lead acid battery might react differently to other cells that are in the battery due to certain factors such as the quantity of charge in each cell is different. Hence during the charging process, this topping charge will help to give a slight overcharge to bring the other cells up to full charge. Topping charge should be applied every six months to avoid voltage drop below 2.10V per cell.

The stronger cells in the battery will absorb the overcharge through the dissipation of heat from the boiling and gassing while the weaker cells will absorb the current from the overcharge until it is sufficient. This topping charge period should be long enough to help pull the cells in the battery up to a fully charged condition. This topping charge is also used to complete the process of fast charging where it is left to charge for at least 30 minutes with a low current. If the battery is used regularly, it will tend to have high leakage current which means when it is left 10 on shelf, the process of self discharging happens rapidly. This high rate of leakage might not attain this low saturation current. A precautionary step should be taken to ensure that overcharging doesn't take place for too long of a time because once the lead acid battery is being overcharged, the electrochemical process will cause it to heat up and boil. The phenomenon of hydrogen gas been let off at the negative cathode plate and oxygen gas being let off at the positive anode takes place due to any charging current beyond that required to liberate the small amount of sulphate radicals from the plates, ionizes the water in the electrolyte. Hence, triggering the process of electrolysis where it separates the water into hydrogen and oxygen gas. While this process occurs to form water vapour, the presence of flammable and potentially explosive hydrogen gas will encourage charging to be done in a well ventilated area. If this is not conducted properly, it will result in a battery explosion due to the hydrogen gas that is being released by the boiling acid. This brings more bad news for sealed lead acid battery where it have a higher chance of an explosion to happen as it has nowhere for the gas to exit hence indirectly building up the pressure in the case leading to an explosion. On the other hand, at low temperature, the electrolyte might freeze up, affecting the performance of the battery. The safe operating temperature for a battery pack is usually 80 Fahrenheit or 26.37 degree Celsius.

C. Float (Trickle) Charge

The float charging is also known as the trickle charging method where its definition is a charging current that can be applied to the battery without damaging it or simply defined as slow charge. This process keeps the voltage at a constant where else the current will be operating at a very low level. The float charge compensates for the self discharging process that happens when the battery is put on shelf where it will self discharge at a rate of 2% - 3% every month. Aging batteries will be issues when the float charge is set due to the different age condition that each of the cells have. This can be seen where a float current that is too high for the aging cell will starve the stronger cells in the same battery causing salvation due to undercharging.

III. ARCHITECTURE

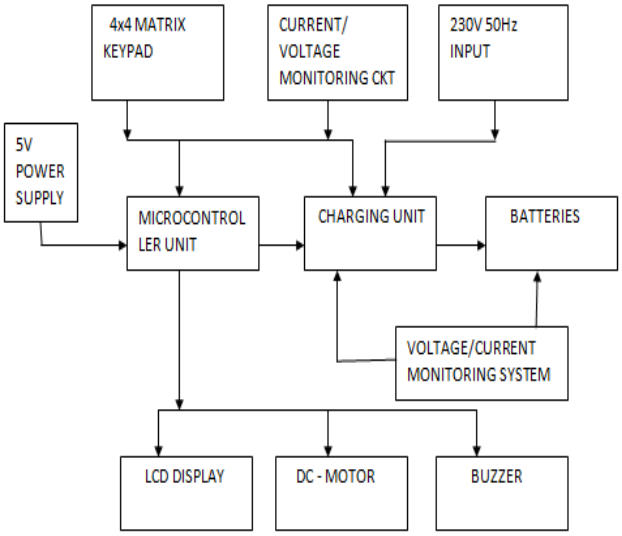

Figure 3 : Architecture of circuit

The main charging unit is the heart of the project. It is to transform AC voltage values coming from network to DC voltage values. The block diagram of this transformation is given below.

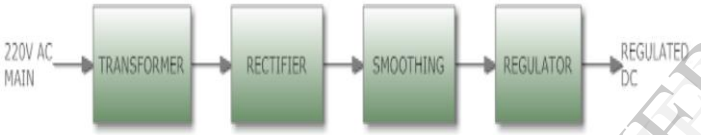

Figure 4 : Block Diagram of charge process

Transformer: Transformers step down high voltage AC mains to low voltage AC. In this step our voltage is still AC.

Rectifier: A bridge rectifier is an arrangement of four diodes in a bridge configuration that provides the same polarity of output voltage for either polarity of input voltage. Rectifier converts AC to DC but the DC output is varying.

Smoothing capacitor: Smoothing capacitors smoothes the DC from varying greatly to a small ripple.

Regulator: Regulator eliminates the ripple by setting DC output to a fixed voltage.

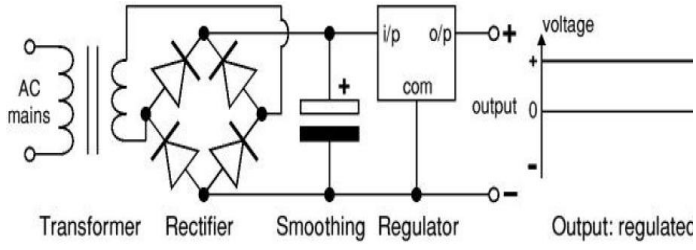

Figure 5 : Output regulated voltage of regulator

A. 18V Transformer: Our battery voltage is 12V plus 3V regulator drop plus 1.4V rectifier drop (2 diodes) plus 10% safety. 12+3+1.4+(12x0.1)=17.6V ~ 18V. Power of the 18V transformer is related to current of the battery to be charged. For
example, the current of a 10watt transformer is 0.55 ampere from the equation current equals to power/voltage. As I said before the charging current is approximately 1/10 and 1/20 of battery capacity but closer to 1/10. So, 0.55 times 10 equals to 5.5 and 0.55 times 20 equals to 11. And since it will be closer to 5.5, 10watt is sufficient for 7A battery.

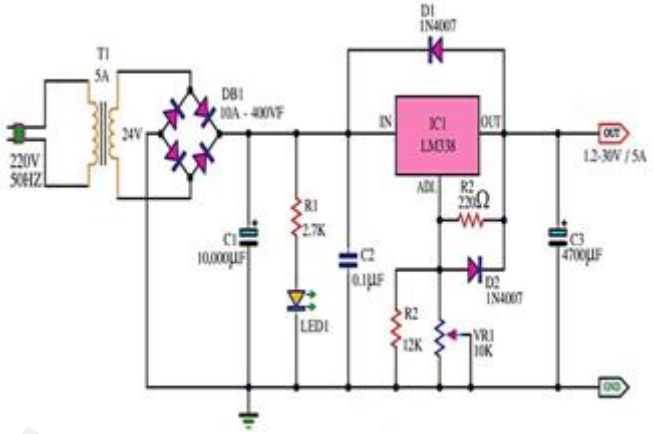

Figure 6 : Charging Unit

B. LM338

The IC1 is the major part of the operation of this circuit. By the voltage output value obtained from the IC depends on the voltage value at the Adj pin of IC1.The LM338 is capable of supplying in excess 5A over a 1.2 to 32 V output range.

C. L298 Motor Driver

The Motor Shield is based on the L298, which is a dual full-bridge driver designed to drive inductive loads such as relays, solenoids, DC and stepping motors. It can drive two DC motors, controlling the speed and direction of each one independently. So three driver circuits are used to drive 6motors. Microcontroller is connected to this driver. Once the battery is fully charged LCD will display “please eject the battery” and so microcontroller gives the signal to L298 to drive the motor out of the drover.

Figure 7 : PCB of Motor Driver

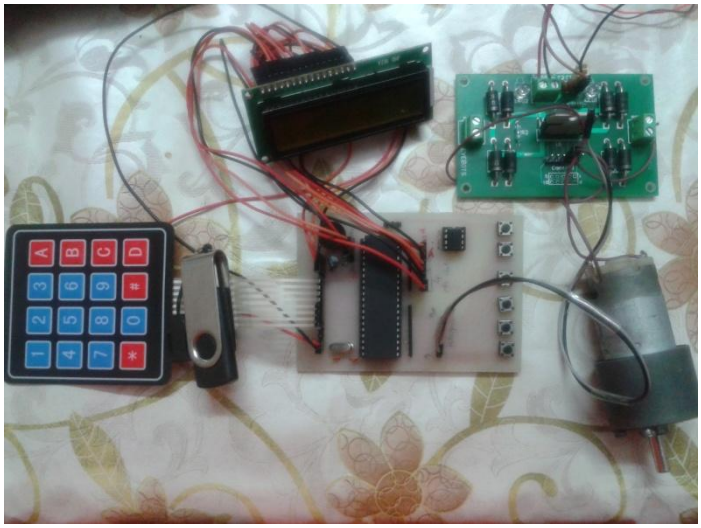

Figure 8 : PCB Testing of PIC MU, LCD, DC Motor

D. PCB Designing

Electronics has an ever green influence in our daily lives. It would not be an exaggeration to say that electronics has become a part and parcel of our lives. Designing in electronics has reached a very high level. Printed Circuit Boards can be rightly termed as the brain–cum-heart-cum backbone of any electronic product. Hence it becomes absolutely necessary that the PCB should be made with the almost care. PCB designing helps to determine most of its limiting properties with respect to noise immunity, fast pulses, and high frequency and low level characteristics of the equipment. Following stages are of great importance from the design point of view.

- Circuit Diagram
- Layout
- Artwork
- Computer Aided Design

The PCB Designing was done in PAD software. And the Fabrication part was done at our college. Fabrication included developing positive and printing was done through screen printing method. The PIC Microcontroller PCB, Power supply PCB, Slave PIC PCBs, Motor Driver PCB, Charging Module PCB were made separately.

E. Microcontroller

A microcontroller is a low-cost processor. Its main attraction is that on the chip itself. It has many other features like in built Analog to digital converter, low power consumption, input output ports etc.in this circuit peripheral Interface Controller i.e. PIC 18f452 is used. It is the brain of the whole system. It is interfaced with LCD, LEDs, Keypad, ADC, Buzzer, Motor Driver circuit which is further connected to DC motors. Master and slave methodology was used to interface the six Batteries for dedicated port.

F. 5 Volt Power Supply

How can I forget the main building block of our circuit the power supply module. For the microcontroller, LCD Display, Motor Driver Circuit, motors. The power supply provides regulated output of +5V & non-regulated output of +12 V.

IV. Software Level

The firmware development for the system operation is done in C language in MP-LAB software. We had made five modules. First to interface LCD with microcontroller. Second was to interface keypad with microcontroller and LCD. Third was to interface ADC module. Then was to interface microcontroller with DC motor to and motor driver module. Last was to interface the LED to the battery to show the charging status of Battery.

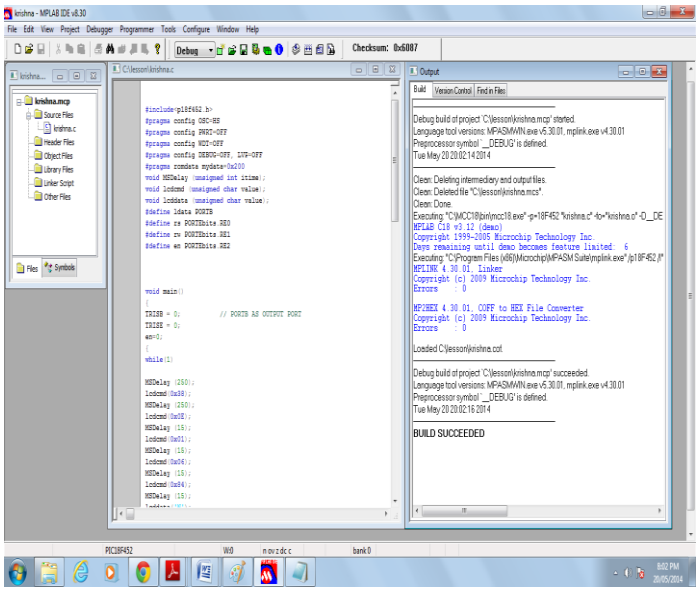

Figure 9 : Software Testing In MP-LAB

V. RESULTS AND DISCUSSION

This paper consists of two sections. One is Software section and the other is Hardware section. In Software section all the testing is done in Proteus Software and by actually implementing it. The individual testing of different modules are developed and the final setup was made arranging all devices in
proper manner. After this final arrangement the whole system was tested and all the six batteries were charged successfully. Finally the product was showing :

- Automatic moving sliders
- Appropriate for 12V sealed-lead acid batteries
- Indication of damaged Battery
- Charging level of Battery Before insertion
- LCD was taking the value of voltage and current manually for charging the battery.
- Facility of fast charging and slow charging as per the need.
- Batteries come out automatically after charging
- Parallel connection of batteries to take out the battery safely without disturbing the other batteries.

VI. CONCLUSION

Implementation of Automatic Battery Charger Station is a new method to overcome from risk of explosion. It has also nullified the problem of battery corrosion. It is quite efficient and reduced the manpower , maintenance and complexity. There is no need to continuously monitor the batteries and switch of from charging.

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