Battery Bank Monitor and Equalizer (BBME)

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***Abstract*—"This paper is intended to provide information of "*BATTERY BANK MONITOR AND EQUALIZER (BBME)" project which gives* real time status of a battery used by automobiles vehicle and equalize the each battery. This paper shows the two main parts of this project. First one is the PIC microcontroller based multi application "In circuit system programmer board" this Embedded board is very useful to program directly with computer. Second one is capacitive active equalizer which is very efficient methodology for equalization of battery.**

Through reviewing the latest methodologies for the state evaluation of batteries, the future challenges for The Battery Bank Monitor and Equalizer" (BBME) are presented and possible solutions are proposed as well.

. Keywords*— Battery, transformer, MOSFET, capacitor, equalizer.

I. INTRODUCTION

As an electrochemical product, a battery acts differently under different operational and environmental conditions. The uncertainty of a battery's performance poses a challenge to the implementation of these functions. This project addresses concerns for current battery management system, state evaluation of a battery, including state of charge, state of health, and state of life, is a critical task for a BBME.

Battery packs for most applications are series strings of electrochemical cells. Due to manufacturing variations, temperature differences, and aging, the individual cells perform differently. When a complete pack is charged and discharged as a single two-terminal circuit element, some cells are chronically overcharged, undercharged, or over discharged, all of which act to reduce cell life. The performance and life of the complete pack is limited by the weakest cell.

This system displays battery level, mains voltage, battery run time, temperature on an LCD. Based on the data obtained, once the voltage drops below a critical level, this system will automatically turn off the power draining loads and connect to equalizer circuit to equalize each battery.

The idea of battery equalizer is to balance the charge level of two batteries by drawing energy from the one with the higher charge and transferring it to the other. The most efficient means of achieving this transfer is by using a switched capacitor. A switched capacitor system for battery equalization can be used with series coupled batteries as well as primary and backup batteries which are alternately compliable to a load.

II. OBJECTIVES

There are four main objectives common to all Battery Management Systems

- Protect the cells or the battery from damage
- Prolong the life of the battery
- Maintain the battery in a state in which it can fulfill the functional requirements of the application for which it was specified.
- Show the status of the battery on LCD display and take the step accordingly

III. BLOCK DIAGRAM OF BBME

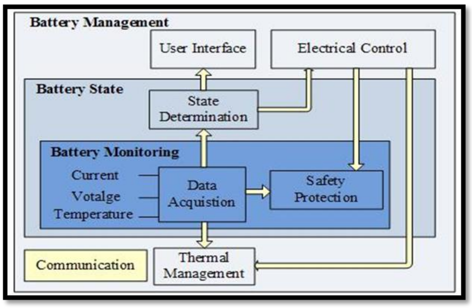


Fig. 1. Block Diagram of Battery Management System

BBME include the following functions:

- Data acquisition
- Safety protection
- Ability to determine and predict the state of the battery
- Ability to control battery charging and discharging
- Cell balancing
- Thermal management

- Delivery of battery status and authentication to a user interface
- Communication with all battery components
- Prolonged battery life

IV.PROJECT DESCRIPTION

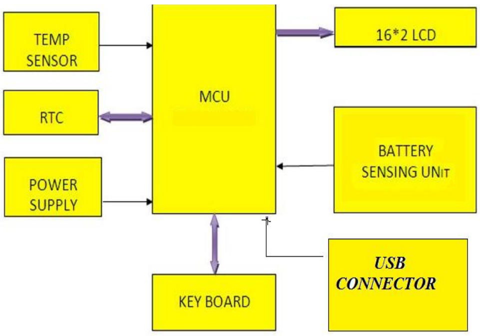


Fig. 2. *USB- microcontroller-programmer-board*

i. Data Acquisition System

1. Microcontroller PIC 18F4550:

PIC 18F4550(shown in fig.2 U2) is a low power, high performance 40 pin PDIP, CMOS 8-bit microcontroller with 32kb flash memory. The important feature of this is it is having an EEPROM Data Memory of 256 bytes. Its other features includes 368 byte of Data Memory, 35 Input Output pins, programmable code protection, 16-bit timer counter with 8-bit prescaler, two 8- bit timer counter with 8-bit prescaler, WDT with its own on-chip RC oscillator for reliable operation and Synchronous I2C port.

2. Real Time Acquisition

RTC DS 1307:

Timing inputs are generated by RTC DS 1307. It is a low power, real-time, full binary-coded decimal clock/calendar having 56bytes of non-volatile static random-access memory (RAM). Address and data are transferred serially via a two-wire, bi-directional bus. The clock/calendar provides seconds, minutes, hours, day, date, and month and year information. Battery connection at pin 3 provides battery backup.

Data is transferred between microcontroller and the RTC using two wires (which from the I2C bus), one of which serves as the clock line (SCL) and the other as data line (SDA). The RTC is driven by an external 32.768 kHz crystal. Sensor System

3. Temperature sensing

LM35:

The LM35 (U1) series are precision integrated circuit temperature sensor, whose output voltage is linearly proportional to Celsius temperature. Its low output impedance, linear output make interfacing to readout easy. It is rated to operate over a range of -55° to 150° C. Its other important features include Linear +10.0mV/°C scale factor and Current drain of less than 60µA.

4. Battery & Mains Voltage Sensing Circuitry:

As per the dividing rule the 12V is converted into 1.58V by the voltage divider circuit comprising the resistors.

Alternative for Battery Voltage Sensing

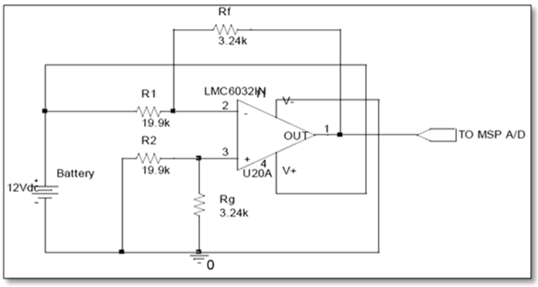


Fig. 3. *Alternate Option for Voltage sensing (lmc6032)*

5. Current sensing

To prevent too much current being drawn from the battery, there must be a way to measure the current flowing in and out of the battery. Normally this is done with a coulomb counter. This is a very sensitive high accuracy ADC that monitors the voltage across a shunt resistor in series with the battery. This is also used for making the gas gauging more accurate. However, in this application it will only be used for safety purposes. The same technique as used for cell voltage monitoring can then be used with a small resistor in series with all the cells. The output from the current sensing device can then be connected to a regular ADC input on the PIC. Care must be taken to get the right input range to the ADC, both considering max voltage to the PIC and maximum current drawn from the battery.

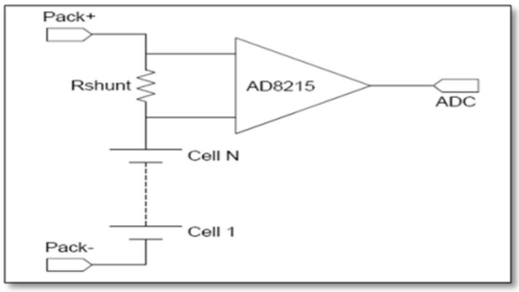


Fig. 4. *Circuit for current monitoring*

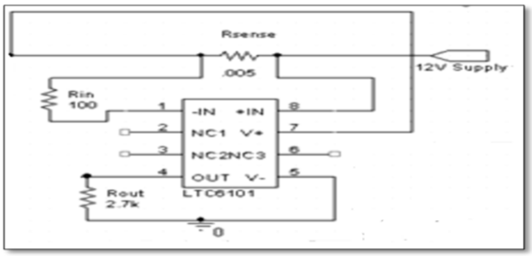


Fig. 5. *Second Alternative for Current Sensing(IC LTC6101)*

6. Battery cut-off circuit

When the current gets to large or when the voltage levels reaches the safe limits, there has to be a circuitry which can prevent any more current flowing. An example of this is shown in figure. The two transistors used are for discharge and charge cut-off. For this circuit, more transistors can be connected in parallel to be able to handle larger currents.

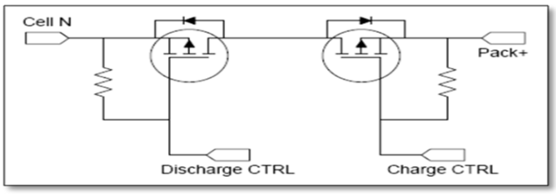


Fig. 6. Circuit for switching off the battery

7. Communication System

Buzzer:

12V buzzer which is connected with the connector J5 is driven by Q2 (transistor BC547). Current limiting resistor R26 is connected at the pin RC2.

8. User Interface

LCD Display:

LCD which is a two-line 16-character alpha-numeric liquid crystal display.

i. Battery equalizer system

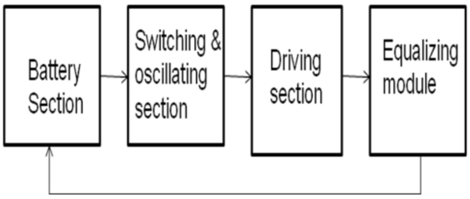


Fig. 7. *Block Diagram*

Fig.7 shows the block diagram. It consists of following block:-

1. Battery
2. Equalizer module
3. Switching circuit
4. Driving circuit

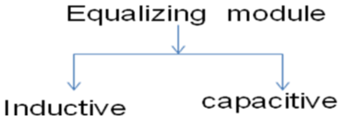
1. Battery:

Fig. 8. *Lead acid battery*

Fig .8. The battery is a lead acid battery of 12V/12Ah. The two batteries are connected in series.

2. Equalizer module:-

Depending upon storing element there are two method of making of equalizing model
Inductive: inductor use to store the transfer energy
Capacitive: capacitor use to store transfer energy.



We choose capacitive equalization process to make battery Equalizer because it is easier than inductive method. And capacitor is better than inductor protection point of view.

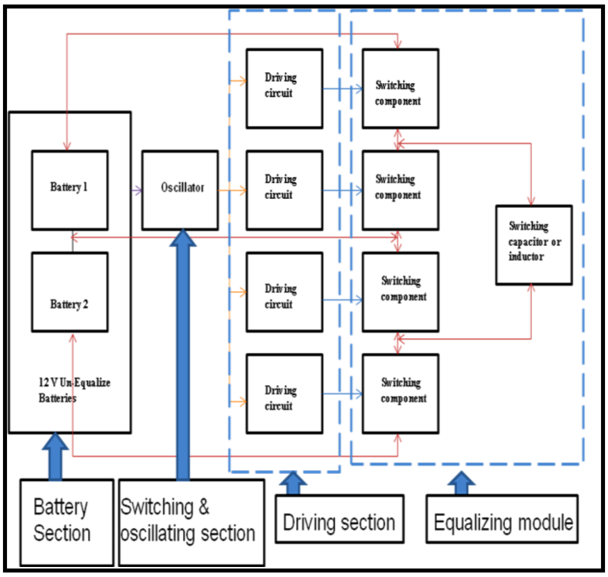


Fig. 9. *Block Diagram Of Capacitive Equalizer*

Fig.9. consists of four MOSFET and one switched capacitor. Battery positive terminal is connected to the drain of first MOSFET and negative terminal is connected to the source of fourth MOSFET. The switched capacitor is between source of first MOSFET and drain of fourth MOSFET.

3. Switching circuit :-

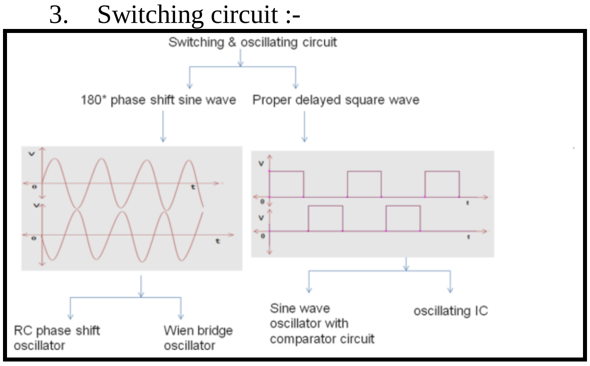
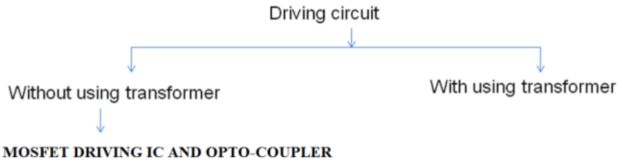


Fig. 10. *Method To Achieve Pulsating Output*

Fig.10.shows the method of delayed pulsating output. First we tried with sine wave generator then chopped that as we required but that becomes complex. So we tried alternate option and we found switching and self oscillating IC. It has

internal adjustment of frequency. It gives two outputs and it is given to the driving circuit.

4. Driving circuit:-



The driving circuit is as pulse transformer driver. The output of switching circuit is given to the input of pulse transformer. This will drive the MOSFET. The output of pulse transformer is given to gate and source of the MOSFET. We test battery equalizer with transformer but for this transformer is very costly and specific for required operation and circuit also become bulky and size of BEQ increases.

For alternatives we also tried transformer less circuit as MOSFET driving IC .This configuration also required isolation component between oscillator and driving part for that we are using specific high speeds opto-coupler IC this part is still under development.

V. EQUALIZER TECHNIQUE

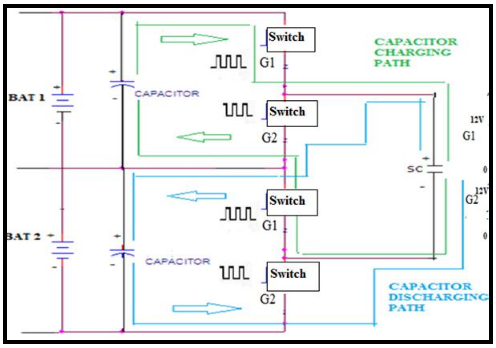


Fig. 11. *Switched Capacitive equalization technique*

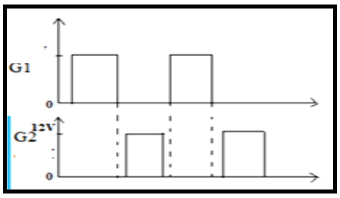


Fig. 12. *Input of G1 and G2 switch*

Fig.12. shows the basic switched capacitor equalization circuit. There are two sets of capacitors. The capacitors directly across the battery terminals decouple inductance in the battery leads, while the others are switched to perform equalization. There are two sets of MOSFETs. Set one (G1) connects the switched capacitors to all of the positive battery terminals, while set two (G2) connects the switched capacitors to the entire negative battery terminal. The two sets are switched alternately.

If battery1 voltage is 12V and battery2 is 11V.Switched capacitor will charged and MOSFET1 & MOSFET3 will be ON. After some time (the delay of 2-3usec) switched capacitor will discharge. This time MOSFET2 & MOSFET4 will be ON.

Selection of SC (switching capacitor):-

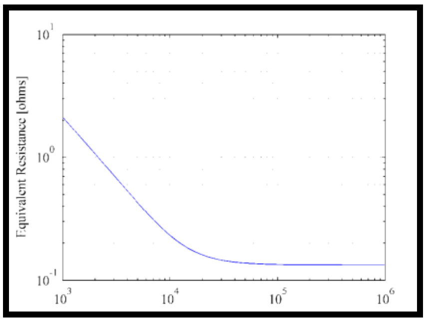


Fig. 13. *Frequency Verses Equivalent Resistance Graph*

Fig.14. shows an equivalent resistance for a SC equalizer using a 470 microfarad capacitor, Total resistance of 30 milliohm D=0.45, as switching frequency varies.

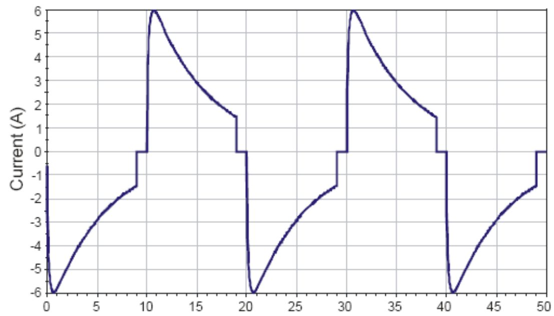


Fig. 14. *Waveform Across Capacitor*

Fig.15. shows current in the switched capacitor equalizer with a 0.1 V differential in the battery cell voltages. Capacitor is 470 microfarad switched at 50 kHz with D=0.45 and a total ESR of 30 ohm.

VI.CONCLUSION

We successfully equalize battery from the above methods, in iron core transformer the difference between the two battery readings came to 100mV and less than that and the consumption is up to 30mA and other future improvement also carried out continuously on this project. We studied about making of monitoring and controlling battery status and going to implement it with modified equalizer with embedded board.

VII. ACKNOWLEDGMENT

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