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Date	: 24.06.2015

BATTERY MONITORING SYSTEM USING ARDUINO IN SOLAR BATTERY CHARGER

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A report submitted in partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

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2015

I declare that this report entitle “Battery Monitoring System using Arduino in Solar Battery Charger” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………………………….

Name : MUHAMMAD SAQIF BIN TALIB

Date : 24.06. 2015

To my beloved mother and father

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ABSTRACT

This thesis present Battery Monitoring System using Arduino in Solar Battery Charger. Battery monitoring system are attractive power systems since the system is using Arduino. It is interesting and a popular form of which is the battery performance can be observed easily. Arduino software can be directly connected to the computer which will make the system simple. The reading will be display on the LCD monitor. The observation and analysis is taken by measuring the voltage of the battery and ampere consumed of the battery during charging and discharging process. Arduino reading will be stored in the SD card to be analysed and the reading is then compared with the fluke meter reading. In addition, a guarantee of a lifespan of the battery is important. Hence, power consumption of load will be considered to calculate lifespan of the battery. The methodology is demonstrated using ISIS Proteus Professional 7. The results provide useful insights and information about coding the Arduino circuit. The expected result of this method can be a significant contribution on financial saving of investment. Lastly, it is necessary for having Battery Monitoring System using Arduino in order to give convenience to user who want to monitor the battery.

ABSTRAK

Tesis ini membincangkan Sistem Pemantauan Bateri menggunakan Arduino dalam Pengecas Bateri Solar. Sistem pemantauan bateri adalah sistem kuasa yang menarik kerana sistem ini menggunakan Arduino. Apa yang menarik dan satu bentuk popular iaitu prestasi bateri yang boleh dilihat dengan mudah. Perisian Arduino boleh terus disambungkan ke komputer yang akan membuatkan sistem kelihatan mudah. Bacaan akan dipaparkan pada paparan LCD. Pemerhatian dan analisis diambil dengan mengukur voltan bateri dan Ampere digunakan bateri semasa proses pengecasan dan nyahcas. Bacaan Arduino akan disimpan di dalam kad SD untuk dianalisis dan bacaan itu kemudiannya dibandingkan dengan bacaan meter Fluke. Di samping itu, jaminan jangka hayat bateri adalah penting. Oleh itu, bacaan penggunaan beban kuasa akan dipertimbangkan untuk mengira jangka hayat bateri. Metodologi yang ditunjukkan menggunakan ISIS Proteus Profesional 7. Hasil tesis ini memberi maklumat yang berguna dan maklumat mengenai pengekodan litar Arduino itu. Hasil yang diharapkan daripada kaedah ini boleh menjadi satu sumbangan yang besar ke atas penjimatan kewangan pelaburan. Akhir sekali, memiliki Sistem Pemantauan Bateri menggunakan Arduino ini merupakan satu keperluan bagi mereka yang ingin memantau bateri.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Motivation

Battery monitoring system in solar battery charger is a new solution that help prevent unplanned outages on critical power backup system. It can provides permanent and continuous monitoring for stand-by battery. Arduino has become the 3rd Industrial Revolution as of today. Arduino has been used as the brains of all sorts of do it yourself (DIY) devices. Hence, this battery monitoring system will use Arduino as a program to monitor the battery. Lastly this battery monitoring system can prevent unplanned outages on critical power backup system.

1.2 Problem Statement

Most of the method to monitor the battery bank is by measuring the battery voltage using a multi meter. Human power is used to monitor the battery from time to time by measure the voltage of each of the batteries. This method are actually inefficient because for big industry they will need many battery bank for safe shut down in case of alternating current (AC) failure. In fact, not many multi meter can save reading. Among the main problem while develop the system are it is hard to communicate between ISIS Proteus Professional 7 and Arduino 1.5.6 because ISIS Proteus cannot read Arduino 1.5.6 file format hence the file need to be convert to other format. Besides, the suitable current sensor for this system is not easy to code. The calibration need to be done.

1.3 Objective

- To study and develop simulation of battery monitoring system circuit in ISIS Proteus 7.
- To produce battery monitoring system using Arduino circuit.
- To check the compatibility of the system.

1.4 Scope

This project is emphasis on the execution of the new equipment which is Arduino. The battery used is 12V Sealed Lead Acid battery. The reading taken are the voltage and current of the battery in different time. The simulation take place in ISIS Proteus Professional 7. The coding was design in Arduino 1.5.6. The reading of Arduino will be compared to other monitoring system. The analysis only take place on DC load.

1.5 Expected Project Outcome

At the end of this project, suitable coding for Arduino can be made. Hence, the user will be able to monitor the battery using Arduino. This is an efficient program for standalone solar system.

CHAPTER 2

LITERATURE REVIEW

2.1 Review of previous works

The articles on solar battery charger stated in the first paper which offers new solar battery chargers for Nickel-Metal Hydride batteries. In the beginning, it is presented that charge control system can be unsuccessful when charging by solar arrays in fluctuating ecological conditions. This paper show the explanations for the disappointment and also produces new innovation on temperature along with voltage based charge control procedures. To rise charge speed, a maximum power point tracker is add up inside the microcontroller of the charger [1]. On the next paper, Standalone Photovoltaic (PV) system needs a suitable charge controller. For this article an effective battery charge controller practice Buck Boost regulator with Maximum Power Point Tracking (MPPT) is obtainable. MATLAB is used to design and simulating this work [2].

Switch to monitoring systems, in the first paper which related to battery monitoring system, project of Battery Monitoring System offer online and offline status condition of batteries which are monitored by the bank. Hence, it can overcome the batteries from failure. However, Battery Monitoring System actually measure, record and analyse only one cell and detail of battery module parameters. To identify battery or cell weakening, continuous analysis and monitoring of these parameters can be used. Therefore this can encourage action to overcome unplanned power outages. Battery Monitoring System also is a microprocessor based intelligent system able to monitor the health of battery bank. BMS monitors battery capacity, drop of batteries in the battery bank all through the life cycle and the real effectiveness of the battery. It uninterruptedly observers each cell in the battery bank to identify drop in the cells earlier to the failure, identify the remaining charge in the battery bank to monitor the discharge and charged currents [3]. On the next paper, Battery management system produce a critical system equipment in several applications such as electric car, hybrid electric car and uninterrupted power supplies. The precision of this system has often been an issue of discussion for researchers commonly gives the maximum error of 10% when considering all the parameters. In this paper a system is built by low price microcontrollers to measure acid temperature, level and backup hour parameters of lead-acid batteries. Although the prototype system that exists today only to measure the remaining time of the car in stationary and in running mode but with this help, it can also determine the lifetime of the battery and battery efficiency. Backup data is also provided to keep a record of all the batteries [4]. Arduino has produced successful results in relation to the inclusion of design and interactive design. When a user has a basic knowledge of Arduino programming language so they can perform a variety of solutions to many problems [5].

2.2 Battery Charger

A battery charger is a device that operate by pushing an electrical current through it. The charge current be determined by the capability of the battery being charged. As an example, current needed to recharge 12 V lead-acid accumulator is completely different to current needed to recharge transportable battery [6]. The circuit style to recharge the battery in a very moveable product may be a main part of any power provide style. The simplicity of the charging system depends on the sort of the battery and also the time required for charging [7]. Rechargeable batteries are required for moveable equipment for instance portable computers and cell phones. Quick charging circuits must cautiously style and depends on the precise battery’s chemistry. The wide held types of rechargeable batteries are Sealed-Lead-Acid (SLA), Nickel- cadmium (NiCd), Nickel-Metal-Hydride (NiMH), and Lithium-Ion (Li-Ion) [8]. Most of the batteries are absolutely charged at 14 to 14.5 volts. On the opposite hand, battery's life time drastically reduces as a result of the discharge over the amount of 70%-80%; at this discharge level the battery voltage ordinarily goes all the way down to 11.5 volts. Every battery features a bound limit of capacity. Battery period reduces drastically as a result of overcharging and deep discharging. As battery may be a terribly high-priced part of a solar Home System, it's necessary to shield the batteries from being over charged or deeply discharged [9]. Even though rechargeable batteries have their energy content restored by charging, some deterioration happens on every charge/discharge cycle. Lead-acid batteries tend to be rated cycles before their internal resistance permanently will increase on the far side usable values. Day by day this resistance will increase that the rated cycle rate additionally decreases and by that the period decreases. Usually a quick charge, instead of a slow nightlong charge, can shorten battery period. However, if the nightlong charger isn't “smart” and can't sight once the battery is absolutely charged, then overcharging maybe, can additionally damages the battery [10].

2.3 Types of Battery Charger

There are several types of battery charger which are simple, trickles, time-based, intelligent, fast, pulse, inductive and USB based. Each of this battery charger have their own specifications. Simple battery charger operates by connecting directly a DC power source to the battery being charged such as solar battery charger. It also does not vary the output based on time or the charge on the battery. This uncomplicatedness refer to cost of the charger is cheap but provide same quality as the expensive one. But normally a simple battery charger takes longer time to charge a battery to overcome severe over charging. The disadvantages of this simple battery charger is if the battery is left for too long it can weakened due to overcharging. These charger can supply constant voltage or constant current to the battery [6]. With restricted information of battery charging, one may believe that a 400Ah battery bank, charged by a 400-amp charger, ought to totally charge from a much discharged standing in concerning AN hour. However, a charger that giant would cause such a lot heat build-up within the battery that it might be fully destroyed before too long [11].

2.4 Solar Battery Charger

Thin-film PV in example amorphous silicon and hybrid dye sensitized or Photovoltaic cells are foremost to new groups of user portable solar arrays. This new arrays are light weight, durable, flexible and have reach power efficiencies of up and about 10% [1].

The most famous renewable energy sources nowadays is the solar energy. Standalone Photovoltaic (PV) system is very popular way of applying solar energy. PV panels are used for converting the sunlight which is solar energy to electrical energy. The voltage power characteristics of the Photovoltaic panel is diverse which depends on temperature and insulation.

In view of the great primary installation charge of the Photovoltaic system, it is essential to work Photovoltaic at its Maximum Power Point. On this reason Direct Current to Direct Current converter is compulsory among Photovoltaic cell and battery [2]. Regardless of of solar power being an honest supply of energy, there's a necessity to boost the strategies to harness this energy [12].

Difference in insolation level causes the output of electrical device deviation from the most power offered as a result of solar position dynamical, the tracker has to response among a brief time to the amendment to avoid energy loss [13].

2.5 Monocrystalline Solar Cell

Lab effectiveness of 25.0% for monosilicon cells are the top in the marketable Photovoltaic commercial, onward of polysilicon with 20.4% and all established thin-film equipment that is CIGS cells (19.8%), CdTe cells (19.6%), and a-Si cells (13.4%). Solar module effectiveness which are often lesser than other matching cells crossed the 20% mark for monoSilicon in 2012 development of 5.5% above ten years. Improved effectiveness shared with economic practice of resources and materials was the main driver for the price drop over the last few years [14].

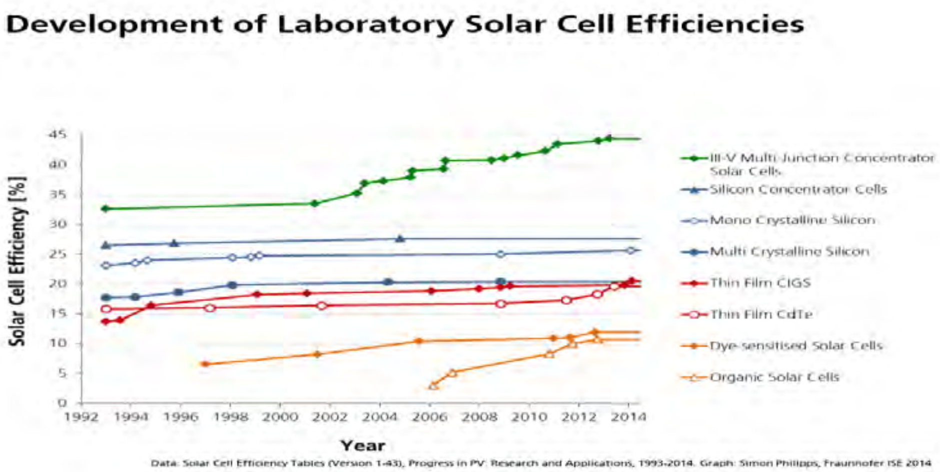

Figure 2.1: Solar cell efficiency courtesy of [14]

2.6 Charge Rate

The charge rate of battery charger is always represented as C and shows a charge or discharge rate equivalent to the capacity of a battery divided by 1 hour. For instance C for a 1200 mAh battery would be 1200 mA. 2C is twice this rate and 1/2C is half the rate [6]. Charging time of battery is calculate as in equation 2.1.

$$T = \frac{Ah}{A} \tag{2.1}$$

Charging current should be 10% of the Ah rating of the battery. Hence, charging current of a battery is calculate as in equation 2.2.

$$I_{charging} = Ah \times \left(\frac{10}{100}\right) \tag{2.2}$$

While it's useful to a battery's performance and life to be totally charged on unvarying occurrences, but once battery has been charged to it's full capacity, it's vital to not continue charging as this may harm the battery [15].

2.7 State Of Charge

A fully charged lead-acid cell has a solution that's a 25th answer of sulfuric acid in water (specific gravity concerning 1.26). A completely discharged lead-acid cell has just concerning no sulphuric acid in its nearly pure water solution (specific gravity about 1.00) [16]. Measurement state-of-charge by voltage is the simplest methodology, however it are often incorrect. Cell varieties have dissimilar chemical compositions that deliver varied voltage profiles. Temperature conjointly plays a job. Higher temperature raises the open-circuit voltage, a lower temperature lowers it, and this development applies to any or all chemistries in varied degrees [17].

Table 2.1: BCI standard for SoC estimation of a maintenance-free starter battery courtesy of [17].

Approximate state-of-charge	**Average specific gravity**	**Open circuit voltage**			
		2V	6V	8V	12V
100%	1.265	2.10	6.32	8.43	12.65
75%	1.225	2.08	6.22	8. 30	12.45
50%	1.190	2.04	6.12	8.16	12.24
25%	1.155	2.01	6.03	8.04	12.06
0%	1.120	1.98	5.95	7.72	11.89

The estimation was with antimony. The readings are taken at room temperature of 26°C.

2.8 Battery Monitoring System

The main objective of Battery Monitoring System (BMS) is to tell the users about the present condition of the battery bank. This can alert the users before the system break down. The most important is the backup time of the battery. On the other hand, if each battery is monitored individually then the action that should be taken if happen any damage can be done in a right time. Besides, other batteries can be safe guarding from damage. On this reason, the lifespan of the batteries can be prolonged. It will access the collected data and generate the various reports such as voltage, charged Ampere-hour, net Ampere-hour discharged during power failure. Then the data will be uploaded to the computer from BMS. Battery monitoring system also gives the graphical representation of each battery to show the behaviour of each battery in a charging and discharging characteristics. BMS shows alarms based on minimum and maximum values which can be set by the user [3]. This BMS use microcontroller as programmer. The design consists of slave unit and master unit which the slave unit will measure the reading from the battery and send the data serially to the master unit. For this experiment, it use 12V battery unit. It have proven that BMS able to measure electrolyte temperature, electrolyte level and backup hours for the battery. It also can record all these parameters and present it on Liquid Crystal Display (LCD) as well as on computer. The system will help to ensure the efficient working of battery [4].

The main part of power protection is reliableness. Issues in power protection will cause serious problems with the top method and may result in vital money losses and even endanger human lives. In nearly each power protection system, the power, throughout the first moments of grid failures, comes from batteries. If batteries are not able to offer the specified power, till alternative protection systems have started or the grid failure has delivered, the availability for the essential load are going to be severely compromised [18]. Mobility and mobile computing systems area unit systems which will simply be physically moved or could also be performed whereas being affected. The little size, restricted memory and process power, low power consumption and restricted property area unit are the most characteristics of mobile devices. The reliance on little devices and also the ones that makes easier the daily tasks will increase on a daily basis. With advances in solar technology, batteries and natural philosophy generally, are more and more attainable to develop new devices that need less energy to work [19].

2.9 Sealed Lead Acid Battery

It is known that short battery life in view of as a significant downside with the device users, by charging it double or a lot of each day [20].

The flooded lead acid battery needs monitoring of the specific gravity of the electrolyte, periodic addition of water to recharge quickly after discharging to overcome hard sulphation which can reasons decrease of capacity. The release of acid fumes by this batteries reasons rusting of metallic materials in the battery. Besides, seepage of acid on the uppermost of cover of the batteries can cause leakage current happen in amplified self-discharge. To avoid these harms, valve-regulated lead acid (VRLA) or sealed lead acid batteries based on oxygen-recombination cycle have developed. Sealed Lead Acid batteries compromise the choice of battery location, cyclability without require for adding electrolyte or monitor the specific gravity. In addition, it is more safety and higher performance. At the positive electrode as in equation 2.3. For negative electrode as in equation 2.4 and equation 2.5 are referring to net cell reaction.

$$PbO_2 + H_2SO_4 + 2H^+ + 2e^- \leftrightharpoons PbSO_4 + 2H_2O \qquad (2.3)$$

$$Pb + H_2SO_4 \leftrightharpoons PbSO_4 + 2H^+ + 2e^- \qquad (2.4)$$

$$PbO_2 + Pb + 2H_2SO_4 \leftrightharpoons 2PbSO_4 + 2H_20 \qquad (2.5)$$

Highest occupied states of reductant must have lower energy than its lowest unoccupied state. Another condition is the lowest unoccupied state of the oxidant must have higher energy than its highest occupied state. If one of this two conditions is disturbed, electrons can be substitutes to or from the electrolyte to decrease it. Thus, the condition for thermodynamic stability of the electrolyte limits thermodynamic window of the electrolyte must be higher than the battery voltage [21].

2.10 Arduino Uno

The Arduino had many advantages which used a scaled down instruction set with many open source reference information such as internet on how to program it. The digital outputs data would show the right time to turn on or off the chargers as necessary. Seems that Arduino is designated for low voltage equipment, it required extra electronics for monitoring voltage divider and current to take the battery voltage depressed to specific range [22]. The Arduino Uno is a microcontroller board based on the ATmega328. "Uno" referred to Italian name to spot the future release of Arduino 1.0. Arduino Uno and version 1.0 will be the reference versions of Arduino, touching onward. Arduino Uno is the newest in a series of Arduino boards and the reference model for the Arduino stage [23].

Figure 2.2: ATMega328 courtesy of [23]

Figure 2.3: Uno board courtesy of [23]

2.11 Arduino C++ Programming

The Arduino integrated development setting (IDE) may be a cross- platform application written in Java. It's capable of compilation and uploading programs to the board with one click. A language reference in Arduino programs which will be divided in 3 main elements that's structure, values for variables with coefficients and functions. It runs computer code compiled from either C, C++, Java4 or the other language that encompasses a compiler for the Arduino tutoring set [24].

2.12 Arduino Current Sensing

The ACS712 is provided in an exceedingly little, surface mount SOIC8 package. The leadframe is plated with 100% matte tin that is compatible with normal lead (Pb) free computer circuit board assembly processes. Inside, the device is Pb-free, apart from flip-chip high-temperature Pb-based solder balls, presently exempt from RoHS. [25].

2.13 Data Presentation

The LCDs have a parallel port, which means that the microcontroller must manipulate many interface pins directly to regulate the display [26].

For 4-bit mode, there are need 6 pins to interface an LCD. Hence, usually need only D4 to D7 which the data pins connection. Other than that, Enable and Register select are for LCD control pins. Read/Write (RW) Pin of the LCD are not connected to any pins as it is made grounded permanently. Moreover, potentiometer is used exactly to control the LCD contrast. For 4-bit mode, other pins are in No-connections which is D0 to D3 [27].

2.14 Data logging

The current time for data-logging functions is providing by the time-keeping circuit generally from 30sec to 99min. Memory card (MicroSD) with 1GB capacity from SanDisk [28] is connected to the microcontroller for storing the sensors readings to store quite one hundred days reading (for 30-second sampling interval). MicroSD cards are offered all-time low these days, a good choice for having an enormous memory in any embedded system project [29].

2.15 Summary and discussion of the review

In previous related works, there are many research have been done to search an optimal solution for minimizing the power failure in the power system. By reviews the literature there are more than 2 types of heuristics method that have been introduced by the previous authors and researches. In recent years, there are many optimization method which have more faster computational time, higher in accuracy and uncomplicated to be setting. In that bombshell, from all previous work the new proposed method battery monitoring system is using programming language and one of the fastest programming software is Arduino.