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Energy Management for Robotic Vehicle Using Tracked Solar Panels

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Abstract: The aim is to construct a optimization charging for lead- acid batteries in the robotic vehicle by means of tracked solar panels. The proposed system is testing on the vanter robotic platform - the autonomous unmanned exploration vehicle is specialized in recognition. On the one hand, it presents the construction of a solar tracking mechanism aimed at increasing the rover's power regardless of its mobility and another proposes an alternative design of power system performance based on a pack of two batteries. There are, one for charging a battery independently from the tracked solar panel and the other battery provides all the energy consumed by the robotic vehicle. By implementing this method, the efficient power management becomes possible. The switching time between the batteries can also be reduced by using matlab coding. The main attraction is to design the concept of the charging and discharging cycles of the batteries. The sensors attached to the battery system will monitor the battery's external parameters and thus the life time of battery can be increased based on the sensors readings. The results are verifying using matlab/simulink environment.

Keywords: *Photovoltaic (Pv), Robotic Vehicle, Solar Tracker*

I. INTRODUCTION

Solar power is the most commonly using renewable energy in electronics field. The concept of battery charging using solar panel has been used for some years. Many rovers are using solar panel for their battery charging. An example for the rover using the solar power for charging is sojourner which have reduced size photovoltaic (pv) panel [1] and the photovoltaic panel doesn't get the enough solar light the batteries cannot be charged [2]. The concept of rechargeable batteries was first used in the mars exploration rovers [3]. Later nasa designed rover for exploration and remote operation also [4]. The example for the remote science exploration and intelligent operation is the k9 rover [5]. Micro 5, a series of robotic exploration vehicle also uses solar panels for lunar exploration [6].

Some noteworthy projects have come whose main advantage is the efficient and optimal selection of solar energy and different sources of energy depends on the area of working [7]-[9]. Hyperion is an example for this type of rover which uses the concept of solar synchronous techniques for the better use of the energy generated by the solar panels [10].

Zoe is also a rover which uses two batteries. The main aim of this rover is to move long distance under tough conditions [11]. The concept of battery switching is used in vanter a rover which have a pair of batteries [14]. The main problems faced in the existing systems were higher photovoltaic size, no battery protection from external environmental conditions and charging and discharging of the battery at a time reduces the life time of the battery.

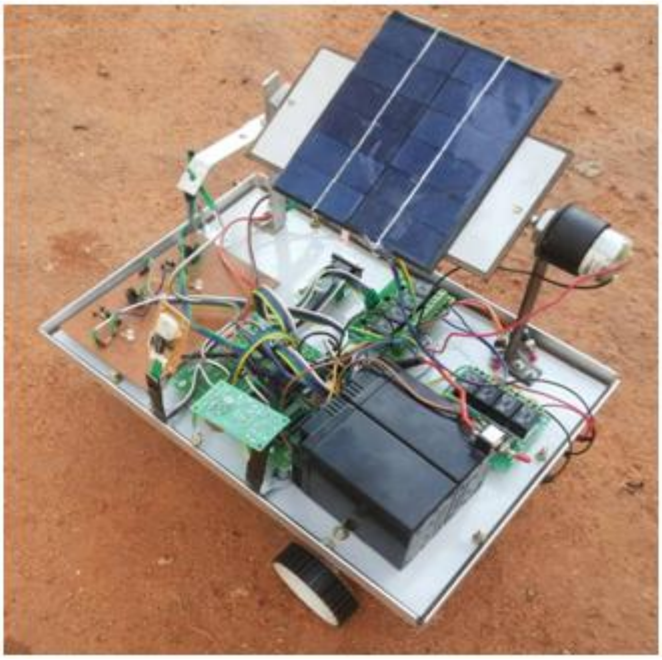

Figure 1: Solar Powered Robotic Vehicle

This paper focuses to improve the operation of aforementioned robotic exploration rovers with intelligent purposes and also with the power system operations. Fig.1 represents the proposed system. The tool used in this proposed system is LCD display for indicating the external parameters like temperature, humidity for monitoring the battery external parameters. LCD also gives the light sensors readings. Controller includes the control switches for the vehicle movement control. The system reduces the size of the pv panels by charging one battery at a time and other will be connected to the load. This paper is presented as follows. The next section is the basic platform, which describes the hardware and software design. After that describes the solar tracking mechanism and the battery section. These sections control the battery charging, discharging and the switching between them based on the tracked solar panels readings. The final section includes the results and developments based on the work.

II. BASIC PLATFORM

The rover consists of four wheels that can rotate independently. Since it can control independently the ackerman configuration and different types of movement are also possible. Each wheel consists of two motors. When the motors rotate in the clockwise direction with constant speed, then the vehicle will move in the forward direction. One motor will used to control the direction of the vehicle by changing its speed. The movement can be achieved by using dc motors (6v and 60ma) that give 120 r/min.

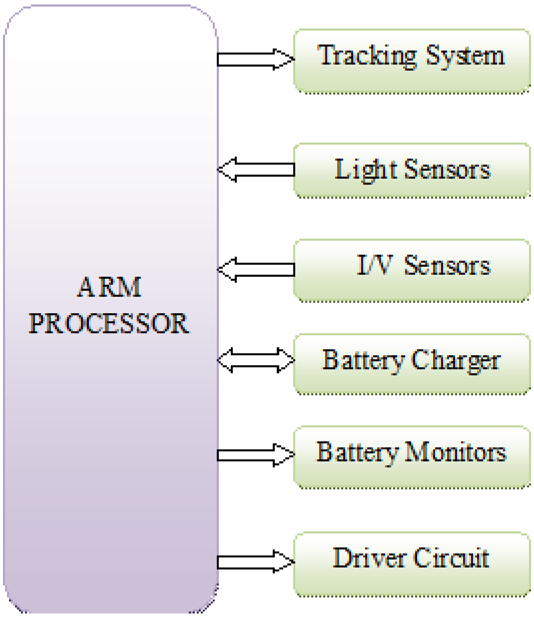

Figure 2: Hardware Architecture

Due to its smaller size and weight the robotic vehicle can be used as a rover vehicle. The basic platform that is the mobile robotic platform consists of hardware and software architectures. The hardware architecture (fig.2) consists of light sensors, solar panel and the power system components. These are designed with hierarchical control structure based on the arm processor. The software architecture consists of one main program code levels. The program code level consists of c language program which runs on a arm lpc2148 processor.

III. SOLAR TRACKING MECHANISM

The selection of solar panels is very important for the efficient power management. The size and weight should be less for the easy control of solar panels. In this paper we have used the monocrystalline solar panels and whose dimensions are 200mm × 250mm × 3.2mm and the weight is 0.7 kg per panel. This paper focuses to track the solar panels according to the increasing power levels in the PV panels. The other systems using navigation techniques to control their panels towards the sun [12] but here, the rover controls its panels towards the maximum powerful light source [20].

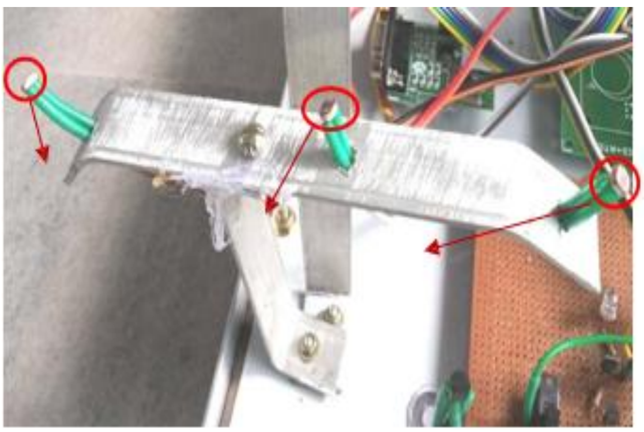

Figure 3: Light Sensors. (a), (b) Side light sensors, (c) Middle Light Sensor

In this paper, three light dependent resistors (LDR) are used to detect the intensity of light. LDR the sensor that varies its resistance depends on the intensity of light falling on it. When the intensity of the light decreases, the resistance of the sensors increases and the intensity of light increases the resistance of the sensors decreases. So it is easy to find the high intensity light source. The arrangement of the sensors is shown in the fig. 3. The face of the sensors can be narrowed by means of opaque plastic tubes to improve the performance of the tracking system.

The motors are used for controlling the solar panel directions by pulse width modulation (PWM) and whose duty cycle determines the required motion. The pulse width modulation duty cycle is determined from the sensors value. The arm processor which gives the sensors readings and also provides the control switches for the vehicle movement.. From the simulation result it is clear that the middle sensor is getting the higher intensity of light so the pv panel will automatically adjust to the horizontal position to get the maximum energy.

IV. BATTERY SECTION

Battery section consists of a pair of lead- acid batteries, charging section. The availability, performance and the cost considering lead acid batteries are well suited for many applications. Fig. 4 shows the pair of lead acid battery. Since lead acid battery contains corrosive acid and some chemicals the chances of leakage of gases and some chemicals are there.

A. Battery Switching Operation

The switching system consists of two max1538EVKIT selectors with break-before-make operation logic. The function of software section is to connect the batteries, charger system and load for charging and discharging purposes (fig. 7). The battery selector 1 routes the current from the pv panels to the input of the charger and also to the battery selected. Selector 1 is placed in between of the charger and the dual-battery pack. Selector 2 connects the battery to the load system. The electrical connections are made by the intelligent micro-controller based on the threshold voltage values that are programmed in it.

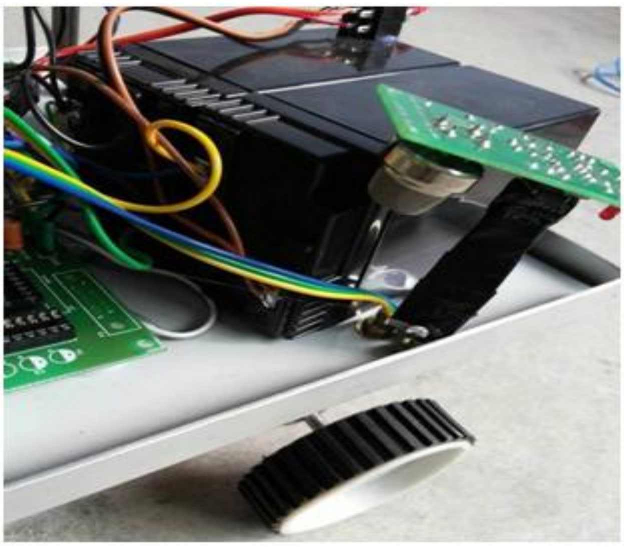

Figure 4: Pair of lead acid battery

The logical operation mode of the battery selectors are shown in the table I. When the battery selector mode is 1 then the battery 1 will be in the charging state. While battery selector mode is 2 then battery 2 will be in the discharging state. In fig. 5 the charge current that obtained from the PV panel is routed to the charger module and the discharging current of the battery is routed to the load system. There is also another feature to operate load by directly using the power from the pv panel. This condition is used when two batteries are fully discharged.

B. Charging and Discharging

The intelligent micro-controller consists of the control algorithm which manages the charging and discharging operation. This is based on MPP(maximum power point) by increasing the output current of the charger module [15].

The MPP tracking scheme is based on the dynamic power path management (DPPM). By this method the voltage variation in the pv panel is detected by the i/v sensor in the charger section as a power variation and these signals are used by the intelligent micro-controller. The intelligent micro-controller enable, disable and control the charger module by means of a pulse width modulated (PWM) signal.

The algorithm in the intelligent micro-controller first checks the power from the PV panel (fig. 7) if it has appropriate power then the intelligent micro-controller increases the output current of the charger up to the maximum regulation current. If the power from the PV panel is low then the intelligent micro-controller immediately reduces the current drawn to the battery until power stabilizes at the power panel.

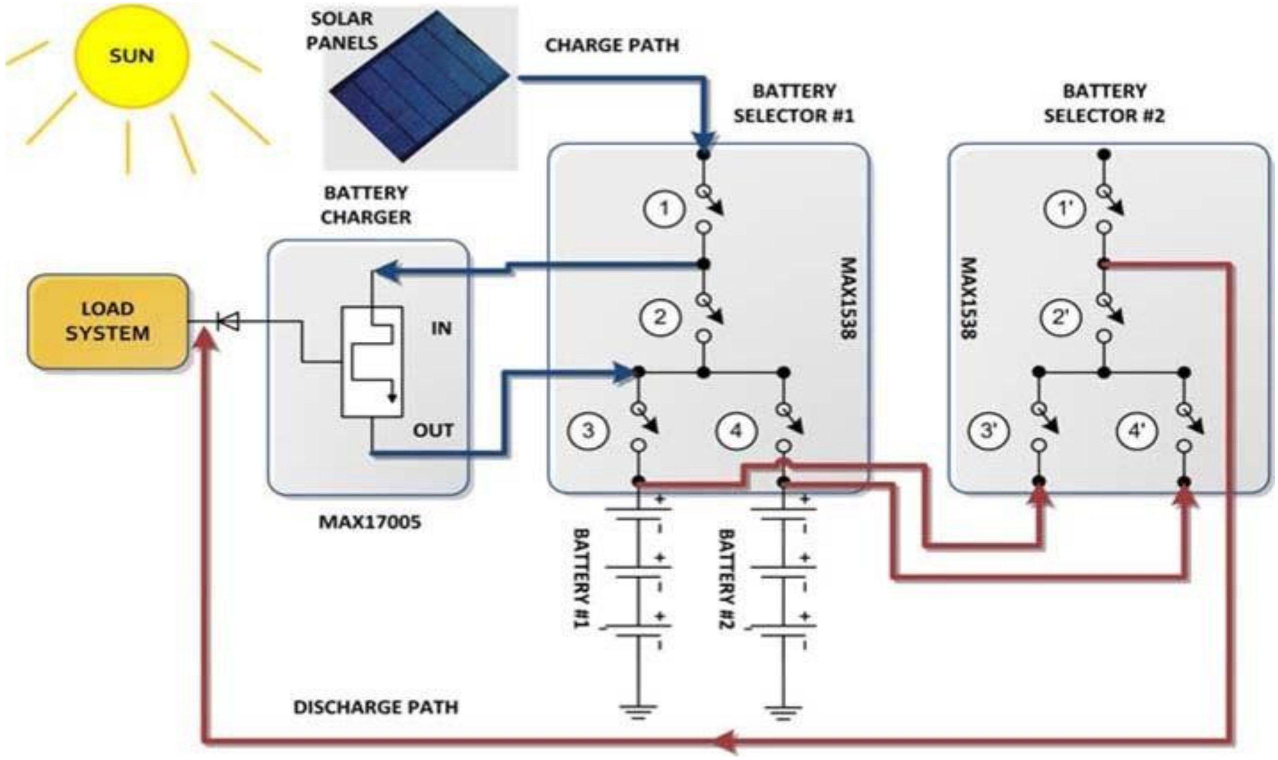

Figure 5: Overall Connection Diagram of Battery Selectors

C. Rechargeable Battery System

This paper proposes two batteries units and is working alternatively. At a time one battery will be charging by using the pv panels current and at the same time another battery will deliver the energy needed for the robotic vehicle. Fig. 6 shows the different strategies of solar powered robots with battery system. In fig. 8 (a) shows dual battery system, (b) shows conventional system, and (c) shows the load sharing system. In this paper the design of independent charging and discharging cycles are implemented. This helps to reduce the size of solar panel since it charging only one battery at a time. The rechargeable system consists of two lead acid batteries. This provides high efficiency, energy density and long life in addition to their low size and weight.

D. Measuring Parameters

The threshold values for the dynamic charging and discharging regulations are defined in the intelligent micro- controller programmed algorithm to prevent lead acid batteries from damaging and to extend their life cycle (fig. 9). The power requirement of the pv system results from the estimation of the voltage and current values that the charger supplies to the battery. The maximum voltage at the charger output is approximately equal to the voltage of the fully charged battery during voltage regulation, which corresponds to v_{OC} =6.6 v

Lead- acid battery emits small amount of hydrogen gas while proper charging. Over charging of lead acid battery can produce hydrogen-sulphide gas. The gas is colorless, very poisonous and flammable. Thus by implementing the gas sensor the batteries life can be monitored. A lead acid battery produces some hydrogen gases also but the amount is minimal when charged correctly. Hydrogen gas is explosive and one would need a concentration of 4% to create an explosion. This level will only be achieved if large lead acid batteries were charged in a seal room. Mq-8 is the sensor used here because it is the suitable sensor to sense hydrogen concentrations in air.

Lead acid battery mainly consists of lead, sulfuric acid and corrosive chemicals. Lead is a toxic metal. If leaked on to the ground, the acid and lead particulars contaminate the soil and become airborne when dry. The sulfuric acid in a lead acid battery is highly corrosive and is potentially more harmful than acids used in other battery systems. Lead acid batteries that are damaged or missing a cap can leak acid. The leakage of these corrosive chemicals results the entire damage of the components in the robotic platform. Humidity is the presence of water in air. The presence of water vapor in air may result the formation of fungi in the battery leads. This will produce loose connection. So humidity sensor is attached near the battery. This will measure the humidity of the environment and also sense the leakages in the battery. Sy- hs-220 is the humidity sensor module used in the system. This module converts the relative humidity in to output voltage. The rated voltage of the sensor module is dc 5v and the operating temperature is 0-60

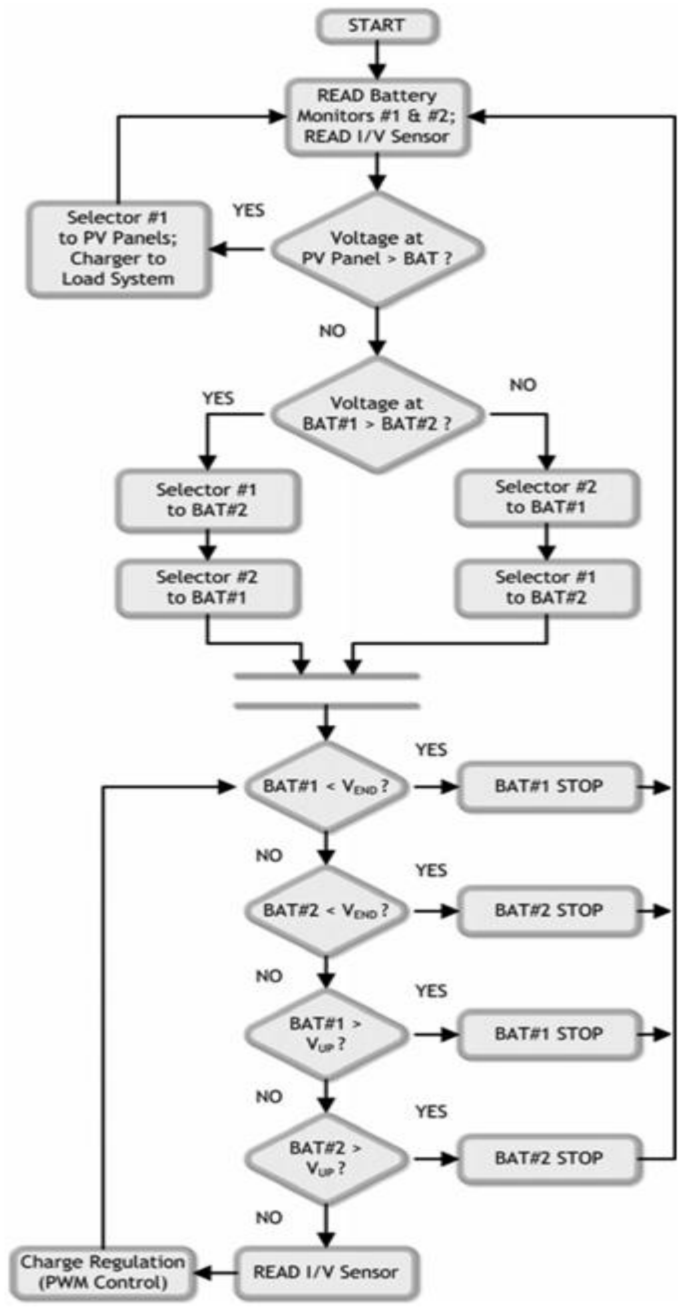

Figure 7: Algorithm of the charging and discharging cycle

CONCLUSION

The main concern is to design an energy efficient system for batteries one who placing in Robotic vehicle. Presented a smart energy management system applied to a robotic platform called VANTER, an autonomous unmanned vehicle devoted to exploration tasks. The one proposal includes the construction of a solar tracker mechanism based on mobile PV panels aimed at increasing system energy. Its main advantage is that amount of generated power is independent from the rover's mobility, since the proposed mechanism is capable of tracking maximum light intensity. Another proposes the charging and discharging periods are taken into consideration. So, by using the two rate charging method to reducing the switching time into one third when compared with taper charging method along with constant current. So, that concluding that by using two rate charging method the efficiency of the batteries are increased and the energy management is effectively can be managed.

References

[1] D. L. Shirley, "mars pathfinder microrover flight experiment—a paradigm for very low-cost spacecraft," acta astronaut., vol. 35, pp. 355–365, 1995.

[2] Brendan peter mcgrath, donald grahame holmes, patrick john mcgoldrick and andrew douglas mciver (2007), 'design of a soft-switched 6-kw battery charger for traction applications', ieee transactions on power electronics, vol. 22, no. 4, pp. 1136-1144.

[3] Bharath pattipati, chaitanya sankavaram, and krishna r. Pattipati(2011), 'system identification and estimation framework for pivotal automotive battery management system characteristics', ieee transactions on systems, man and cybernetics, vol. 41, no. 6, pp. 869-884

[4] Chian-song chiu (2010), 't-s fuzzy maximum power point tracking control of solar power generation systems', ieee transactions on energy conversion, vol. 25, no. 4, pp. 1123-1132.

[5] Cody a. Hill, matthew clayton such, dongmei chen, juan gonzalez and w.mack grady(2012), 'battery energy storage for enabling integration of distributed solar power generation', ieee transactions on smart grid, vol. 3, no. 2, pp. 850-857

[6] Feng ju, junwen wang, jingshan li, guoxian xiao and stephan biller (2013) 'virtual battery: a battery simulation framework for electric vehicles' ieee transactions on automation science and engineering, vol. 10, no. 1,pp. 5-15

[7] Henry shu-hung chung, ieee, k. K., ieee, s. Y. Ron hui, c. M. Mok, and m.t.ho (2003), 'a novel maximum power point tracking technique for solar panels', ieee transactions on power electronics, vol. 18, no. 3, pp.717-724

[8] Huang, fangxing li, zhiqiang jin(2007), 'maximum power point tracking strategy for large-scale wind generation systems considering wind turbine dynamics', ieee transactions on industrial electronics, pp.1-10.

[9] Jean-charles matéo-vélez, jean-françois roussel, david rodgers, alain hilgers, marc sévoz, and patrice pélissou (2012), 'conceptual design and assessment of an electrostatic discharge and flashover detector on spacecraft solar panels', ieee transactions on plasma science, vol. 40, no. 2, pp. 246-253

[10] Jian-long kuo, kai-lun chao, and li-shiang lee,(2010),'dual mechatronic mppt controllers with pn and opso control algorithms for the rotatable solar panel in phev system', ieee transactions on industrial electronics, vol. 57, no. 2, pp.678-689

[11] Mummadi veerachary(2011), 'fourth-order buck converter for maximum power point tracking applications', ieee transactions on aerospace and electronic systems, vol. 47, no. 2, pp. 896-911.

[12] Mukesh ranjan, naresh kumar parshottambhai vaghela, subroto mukherjee, muthusamy sankaran and suresh edekkepravan puthanveettil (2013) 'arc mitigation via solar panel grouting and curing under simulated leo-like plasma environment', ieee transactions on plasma science, vol. 41, no. 12, pp.3323-3328.

[13] Nojan aliahmad, mangilal agarwal, sudhir shrestha and kody varahramyan(2013), 'paper-based lithium-ion batteries using carbon nanotube-coated wood microfibers', ieee transactions on nanotechnology, vol. 12, no. 3, pp. 408 – 412

[14] Pooja sharma and vivek agarwal (2014), 'exact maximum power point tracking of grid-connected partially shaded pv source using current compensation concept', ieee transactions on power electronics, vol. 29, no. 9, pp. 4684-4692

[15] Thomas peter,tharek abd rahman, s. W. Cheung, rajagopal nilavalan, hattan f. Abutarboush and antonio vilches(2014), 'a novel transparent uwb antenna for photovoltaic solar panel integration and rf energy harvesting' ieee transactions on antennas and propagation, vol. 62, no.4, ,pp.1844-1853.

[16] Tom´as de j. Mateo sanguino and justo e. Gonz´alez ramos(2013), 'smart host microcontroller for optimal battery charging in a solar-powered robotic vehicle', ieee/asme transactions on mechatronics, vol. 18, no. 3, pp. 1039-1049.

[17] Tom mathews and v. Gopi(2014), 'embedded system based power management for battery operating robotic vehicle', international conference on circuit, power and computing technologies [iccpct], pp. 503 -508.

[18] Xiao li, yaoyu li and john e. Seem(2013), 'maximum power point tracking for photovoltaic system using adaptive extremum seeking control', ieee transactions on control systems technology, vol. 21, no. 6, pp. 2315-232

[19] Ye yuanmao, k. W. E. Cheng and y. P. B. Yeung(2012), 'zero-current switching switched-capacitor zero-voltage-gap automatic equalization system for series battery string' ieee transactions on power electronics, vol. 27, no. 7, pp. 3234-3242.

[20] Ying-chun chuang and yu-lung ke(2007), 'a novel high-efficiency battery charger with a buck zero-voltage-switching resonant converter' ieee transactions on energy conversion, vol. 22, no. 4, pp.848-854.