International Journal of Advanced Technology and Innovative Research

www.ijatir.org

ISSN 2348–2370
Vol.08,Issue.05,
May-2016,
Pages:0923-0928

The Design and Implementation of Optimal Battery Charging Robot Using Solar Power

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Abstract: This paper focuses on the design and construction of anoptimization charging system for batteries by means of tracked solar panels. Thus, the implementation of a complete energy management system applied to a robotic exploration vehicle is put forward. The proposed system was tested on the robotic platform—an autonomous unmanned exploration vehicle specialized in recognition. The interest of this robotic system lies in the design concept, based on a smart microcontroller. On this basis, our proposal makes a twofold significant contribution. On the one hand, it presents the construction of a solar tracking mechanism aimed at increasing the rover's power regardless of its mobility. On the other hand, it proposes an alternative design of power system performance based on a pack of two batteries. The aim is completing the process of charging a battery independently while the other battery provides all the energy consumed by the robotic vehicle. In this the ARM interfaces with LDRS, DC motors, wireless module, battery switching circuit and monitor circuit. LDR is used to calculate light intensity and based on this the controller changes the solar panel direction using DC motor. And another two DC motors acts as robot and this robot can be controlled through wireless network. The solar panel takes the complete solar energy and that can be stored in battery and one more battery to run the DC motors of robot. Whenever the power consumed completely in one battery then switch to another one using switching circuit. The batteries can monitor through battery monitor circuit. Wireless camera is also used to capture the pictures around.

Keywords: Li–Po Battery, Robotic Vehicle, Mechatronic System, Photovoltaic (PV), Solar Tracker.

I. INTRODUCTION

SOLAR Power Systems In Autonomous Robotic Vehicles Have Been Often Used For Some Years. A Real Example Is The Sojourner Rover, In Which Most Of The Supplied Energy Is Generated By A Reduced-Size Photovoltaic (PV) Panel [1]. However, In Case Of Scarce To No Solar Light, The Rover Should Minimize Consumption, Since Its Batteries In Line Could Not Be Recharged When Depleted [2]. The Use Of Rechargeable Batteries In A Space Mission Was Used For The First Time In The Mars Exploration Rovers. Nevertheless, The Need For Greater Operation Autonomy By Spirit And Opportunity Was Solved By Means Of Larger Deploy Solar Panels [3]. This Solution Works As The Basis For The Design Of Solar Panels For The Future Exomars Mission. This Rover, Thanks To Its High-Efficiency Ultrathin-Film Silicon Cells Constructed On Carbon-Fiber Reinforced Plastic, Is Capable Of Providing Higher Power [4], [5]. NASA Designs Inspired Different Generations Of Exploration Vehicles [6]. This Is The Example Of K9, A Rover For Remote Science Exploration And Autonomous Operation [7]; Field Integrated Design And Operations, An Advanced-Technology Prototype By Jet Propulsion Laboratory For Long-Range Mobile Planetary Science [8]; And Micro5, A Series Of Robotic Vehicles Devised For Lunar Exploration [9]. As Its Main Design Advantage, This Rover Series Has A Dual Solar Panel System Coupled To An Assisted Suspension Mechanism.

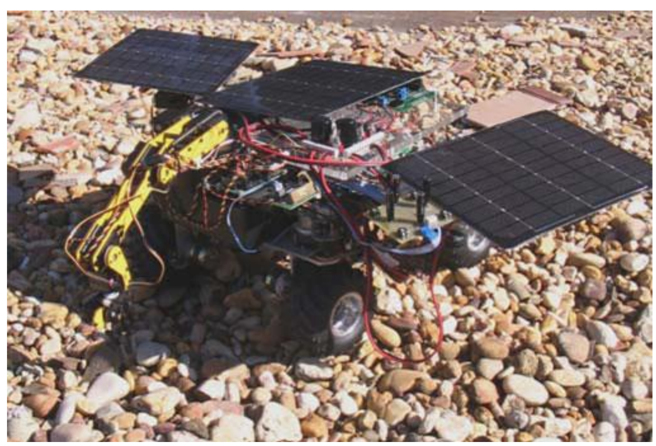

Fig.1. VANTER: A Solar-Powered Robotic Vehicle

This Prevents The Manipulator Arm Mounted On The Middle Of The Rover From Having To Minimize Solar Panel-Generated Power And Allows It To Dust Solar Panel Surface. Other Robotic Exploration Vehicles Have Also Been Developed In Academic Spheres. This Is The Case Of SOLERO, Developed By The Ecole Polytechnique F´Ed´ Erale De Lausanne, Which Reached Optimal Energy Consumption by a Combination of a Smart Power

Management and An Efficient Locomotion System [10], [11]. On The Other Hand, the Carnegie Mellon University Developed Hyperion, A Rover In Which the Major Technological Milestone Was the Implementation of Solar-Synchronous Techniques To Increase The Amount Of Energy Generated By Solar Panels [12]; And Zo¨E, A Rover Capable Of Long-Distance Traverses Under Extreme Environmental Conditions Devoted To Science Investigation At The Atacama Desert [13]. With An Educational Approach, Carnegie Mellon University Also Developed A Personal Exploration Vehicle Called Per [14]. More Recently, Lever And Coworkers [15] And [16] Have Described The Concepts Of Modeling, Design, And Fabrication Of A Robot-Box Prototype To Be Used In Polar Environments. The Platform—Known As Cool Robot—Uses A Control Algorithm Of Maximum Power Point (Mpp) Aimed At Maximizing System-Supplied Power For Five Pv Modules Designed As A Cube. Finally, There Are Some Noteworthy Projects Which Main Achievement Is The Optimal Selection Of Solar Energy And Different Power Sources According To The Operation Conditions Of A Robot [17]–[19].

The Vanter Robotic Exploration Vehicle Aims To Improve Various Aspects Of The Aforementioned Rovers With Scientific And Academic Purposes. To Introduce The Developed Robot (See Fig. 1), The Main Features And Properties Are Compared In Table I. Subsequently, This Paper Is Organized As Follows. The Next Section Presents The Mobile Robotic System. Its Main Features Are Described And Its Hardware And Software Architecture Are Presented. Section Iii Introduces The Concept Of Smart Host Microcontroller (Shm) For Intelligent Power Management Applied To An Exploration Vehicle. The Following Sections Present The Control Of The Battery-Charging System By Means Of Tracked Solar Panels, Which Is The Main Aim Of This Paper; The Design Of Its Mechanical Structure, Its Electronic Devices And The Graphical User Interface (Gui) Are Presented. Section Iv Aims At Providing The Necessary Parameters For The Batteries Sizing, Charging, And Discharging Algorithm, And The Pv System Sizing. Therefore, Section V Puts Into Practice The Developed Methodology By Testing The Rover Power Systems. Finally, The Results And Findings From The Developed Work Are Presented.

II. MOBILE ROBOTIC PLATFORM

VANTER—Spanish Signifier For Autonomous Remote-Controlled Exploration Vehicle Specialised. In Recognition is A Robotic Exploration Vehicle Developed At The University of Huelva, Huelva, Spain. The Rover Was Developed To Be Guided And Features A Set Of 4 Wheels Coupled To A Plane Chassis Which Will Rotate Severally. The Four-Wheel-Drive (4WD) And Also The Individual Management Of Every Wheel Permit Differing Types Of Movement; Together With Ackerman Configuration, The Crabbing Maneuver Or The Rotation With Inner Mechanical Phenomenon Center. The Four Wheels In VANTER Square Measure Sustained By Suggests That Of Freelance Passive Suspension Of Double Metallic Element Fork To Soak Up Piece Of Ground Vibrations. Every Wheel Consists Of 2 Motors, One For Rotation And Another For Driving. On The One Hand, Forward Movement Is Made By Suggests That Of Dc Motors (12 V And Sixty Ma) That Has One Hundred Twenty R/Min With A Torsion Of Eight.87 Kg/Cm. On The Opposite Hand, The Rotation Motor Provides A Speed Of 152 R/Min Among Others Instruments Aboard VANTER Disposes Of A 5-DOF Robotic Arm, Associate Omni Vision MC203 Wireless Micro Camera, Associated An Analog Video Receiver With A Pinnacle Dazzle DVC100 Video Capture Card. Its Reduced Weight, Tiny Dimensions, And Flexibility Create VANTER Appropriate As A Robotic Exploration Vehicle. The Robotic System Programming Is Split Into 3 Main Code Levels And Its Hardware Was Designed With A Gradable Management Structure Supported Standard Microcontrollers. The Highest Level Program, Applied In Lab VIEW Language, Is Dead In An Exceedingly Remote Laptop And Offers A GUI To Observe And Management The Complete Robotic Vehicle. The Second Code Level, Programmed In C Language, Runs Autonomously On A Master PIC16F876A Microcontroller Aboard VANTER. Communication With The Remote Laptop Is Performed By Victimisation A UHF Modem For The Centralized Management Of Rover Functions. The Third Code Level Consists Of Many Slave Microcontrollers Distributed In Associate I2C Network Geared Toward The Distributed Management Of The VANTER Driving Functions (4×PIC16F88), Remote Manipulation, And Power Management.

III. MECHATRONIC SYSTEM DESIGN

A Typical Power Management Style Consists Of Sensible Batteries Group Action Each Communication Devices And Natural Philosophy Able To Management The Charge. However, Once A Cost-Effective System Is Needed, The Thought Of Intelligence Ought To Be Applied To Software System Style For Easy Batteries. One Amongst The Most Objectives Of This Paper Is That The Implementation Of The SHM Thought To Develop A Low-Priced Power Management System Aboard A Robotic Vehicle. The System Consists Of Associate Electric Circuit Interconnecting A PV System, A Charger Device, A Selector System, A Batteries Monitor System And Electric Battery System (See Fig. 3). The SHM Relies On A PIC16F886 Microcontroller That Monitors VANTER Consumption And Choices In An Exceedingly Fully Autonomous Means. The SHM Has 2 Main Functions: 1) Police Investigation Environmental Light-Weight Level And Dominant The Star Chase System To Get The Very Best Power; And 2) Deciphering Operation Information From Batteries And Star Panels To Manage The Operating Mode Of The Charger Consequently. The Value Of This System—Regardless Of The Navigation Instruments And VANTER Software—Is US$ 600. The PV System Provides Power, Keeping In Mind That Voltages And Currents Generated Should Adapt To The Most And Minimum Values Of The Hardware.

However, Since The Environmental Natural Options Can Not Be Foreseen At Every Instant, The Quantitative Energy From Radiation Can Not Be Foreseen Either. Thus, One Amongst The Most Proposals Of This Paper Is That The Implementation Of A Star Chase Mechanism Geared Toward Increasing Power Levels Within The PV Panels. In Contrast To Different Rovers That Use Navigation Techniques To Guide Their Panels Toward The Sun,VANTER’s Quality Doesn't Represent A Drawback, Since The Projected Huntsman System Appearance For The Foremost Powerful Source Of Illumination. Star Huntsman Prototypes Inbuilt Mobile Robots Have Evidenced That Orientation Of PV Systems Results In Hyperbolic Energy Potency Relative To Systems With Fastened Star Panels (20– 50% Per Collector). This Gain Depends On Many Construction Methods Of The Star Huntsman Like The Kind Of Axis Movement (Either Single Or Dual), Kind Of Sensors On That Relies (Photoresistors Or Electrical Conduction Cells), And Also The Accuracy Rendered By The Quantity Of Device Pairs. On The Contrary, Parasitic Load Consumption Associated To The Projected Configuration (A Mobile Solar Array, 2 Batteries, And Electronics) Compared To An Easy System (A Fastened Panel, A Battery, And Electronics) Is Hyperbolic Between One.14% And 21.42%. The Consumption Increment Varies Primarily Owing To The Operation Of The Star Chase System, That Relies On Servos; Therefore, Customary Dc Motors Is Projected To Scale Back The Consumption Up To Eight.57%. The Inexperienced Energy Conjointly Referred To As The Regeneration Energy, Has Gained Abundant Attention These Days. Inexperienced Energy Are Often Recycled, Very Similar To Solar Power, Water Power, Wind Power, Biomass Energy, Terrestrial Heat, Temperature Distinction Of Ocean, Sea Waves, Morning And Evening Tides, Etc.

Among These, Solar Power Is That The Most Powerful Resource Which Will Be Wont To Generate Power. Up To Now The Potency Of Generating Power From Solar Power Is Comparatively Low. Thus, Increasing The Potency Of Generating Power Of Solar Power Is Extremely Necessary. Within The Past, Star Cells Are Hooked With Fastened Elevating Angles. They Are Doing Not Track The Sun And So, The Potency Of Power Generation Is Low. For Instance, The Elevating Angle Of A Cell For The Most Important Volume Of Illumination In Daytime Is Twenty Three.5°In Southern Taiwan. Since The Fixedtype Solar Array Can't Acquire The Optimum Solar Power, The Transformation Potency Of Solar Power Is Restricted. Several Students Have Projected Totally Different Ways For Chase The Sun [3-9]. Many Various Source Of Illumination Sensors, Candlepower Sensors, Intelligent Vision Techniques, And Ccd Equipments Were Applied To Reckon The Absorbed Time Of The Sun Radiation In Everyday For Measurement The Quantity Of Solar Power. Up To Now The Bulk Of Cell Panels Worldwide Square Measure Hooked With Fastened Angles. Thus, It's Clear That The Strategy Of Chase The Sun Could Be A Technique Merit Being Developed. During This Paper, The Most Goal Is To Style And Implement A Star Chase System Victimisation Field Programmable Gate Array (Fpga). The Cds Light-Weight Sensitive Resistors Square Measure Used. Feedback Signals Square Measure Delivered To The Allotted Chip Through Associate A/D Device. From The Experimental Results, The Projected Chase System Is Verified A Lot Of With Efficiency In Generating Energy Than The Fastened System

The Cell Consists of The Semiconductors Of The P-N Junctions. It Will Convert Light-Weight Into Electrical Energy. Thus We Will Assume That Electricity Made Victimisation Daylight Shining On The Cell Are Often Used Like Common Electricity. The Equivalent Circuit Of The Cell Is Shown In Fig. 1. The Present Offer I Ph Represents The Electrical Current Generated From The Sun Beaming On The Cell. Rj Is That The Non-Linear Ohmic Resistance Of The Contact. Dj Could Be A Contact Diode, Rsh And Rs Represent The Equivalent Lineup With The Inside Of The Materials And Connecting Resistances Asynchronous. Sometimes Generally Analysis, Rsh Is Giant, And Also The Worth Of Rs Is Tiny. Thus So As To Modify The Method Of Research, One Will Ignore Rsh And Rs . The Image Artificial Language Represents The External Load. I And V Represent The Output Current And Also The Voltage Of The Cell, Severally. From The Equivalent Circuit, And Supported The Characteristics Of The Contact, (1) Presents The Association Between The Output Current I And Also The Output Voltage V : Where Np Represents The Parallel Whole Number Of The Star Cell; Ns Represents The Series Connected Whole Number Of The Star Cell; Alphabetic Character Represents The Contained Electricity In Associate Electro (1.6×10^{-19} Columbic); K Is That The Ludwig Boltzmann Constant (1.38×10^{-23} J / °K); T Is That The Temperature Of The Cell (Absolute Temperature °K); And A Is That The Ideal Issue Of The Cell (A = One ~ Five). The Present Sat I In (1) Represents The Reversion Saturation Current Of The Alternative Energy. Further, Sat I Are Often Determined By Victimisation.

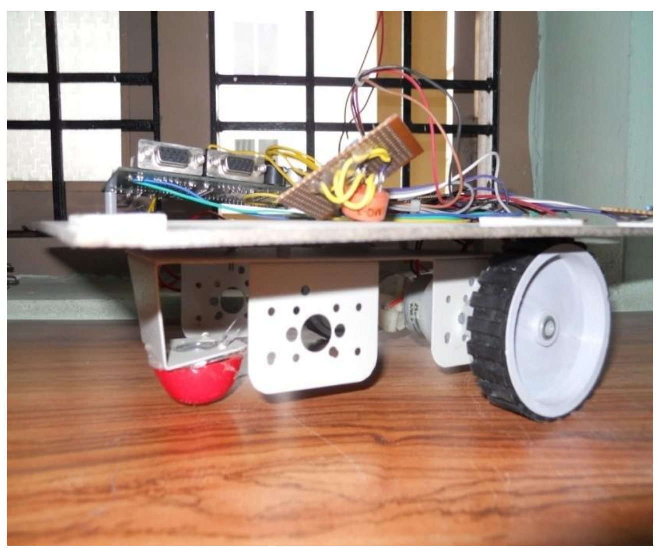

Fig.2. Robot Flat Form.

The Subsequent Formula: Where Tr Represents The Reference Temperature Of The Cell; Irr Is That The Reversion Saturation Current At The Time Once The Star Cell Reaches Its Temperature Tr ; And Egap Is That The Energy Required For Crossing The Energy Band Gap For The Semiconductor Materials. (The Crystalline Egap ≅ One.1ev). From The Study We Tend To Square Measure Able To Recognize That Once The Temperature Is Fastened, The Stronger The Daylight Is, And Also The Higher The Open-Circuit Voltage And Short-Circuit Current Square Measure. Here We Will See The Apparent Effects Of Illumination On The Short-Circuit Current, Instead Of The Open-Circuit Current. Thus The Cell Will Offer Higher Output Rate Because The Daylight Becomes Stronger, I.E. Cell Facing the Sun.

IV. IMPLEMENTATION DETAILS

The Main Focus of The Project Is Alternative Energy System Will Be Attending To Operate The Automaton. We Tend To Square Measure Attending To Interface Choose And Place Arm With Automaton.

Fig.3. Solar Panel.

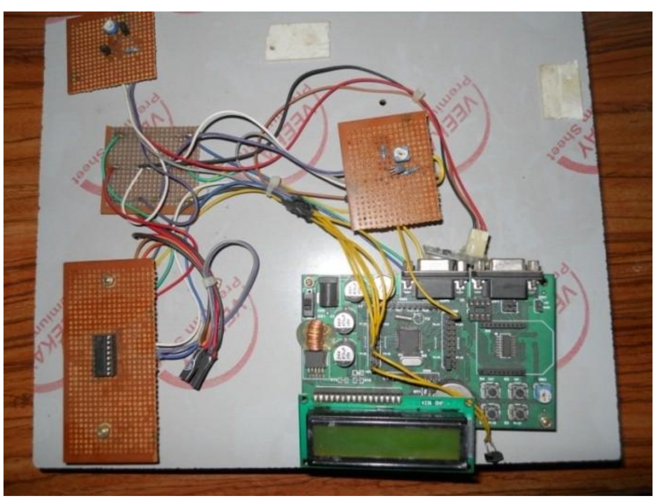

Fig.3. Microcontroller Base Kit.

Thus The Functions of Robotic Vehicle Are Wont To Perform Another Operation That Is To Choose And Place Any Objects. For This The Ability Management Can IncorporatesSmart Battery That Mixes Each Communication Devices And Natural Philosophy That Square Measure Able To Management The Charge. To Realize This Economical System, Intelligence Are Applied To Software System Style For Simple Batteries. Therefore Our Main Objective Is To Implement Sensible Microcontroller For Low Value Management System On Board A Robotic Vehicle With Pick And Place Arm. Power Management System Consists Of Electrical Phenomenon System, A Charger Device, Selector System And Battery System.

V. CONCLUSION

This Paper Has Presented A Smart Energy Management System Applied To A Robotic Platform Called VANTER, An Autonomous Unmanned Vehicle Devoted To Exploration Tasks. The Proposal Includes The Construction Of A Solar Tracker Mechanism Based On Mobile PV Panels Aimed At Increasing System Energy. Its Main Advantage Is That The Amount Of Generated Power Is Independent From The Rover's Mobility, Since The Proposed Mechanism Is Capable Of Tracking Maximum Light Intensity. Delivering The Systems' Energy Requirements While Recharging The Backup Battery Was Made Possible By Implementing A Dual System Of Selectors, Monitors, And Batteries. This Strategy Implies Small Solar Panels To Power A Single Battery At A Time. A Relatively Good Compromise Between Total Weight, Capacity Available, And Source-Required Power Is Reached. This Solution Does Not Attempt To Achieve High Charging Times Or Great Operating Times But To Prove A Sustainable And Commercially Feasible Solution Applied To A Robotic Vehicle. In This Sense, An SHM Was Designed For Optimal Charge Regulation By Means Of An Mpptracking Scheme Based On The DPPM. Experimentation Shows That The Charging And Discharging Processes That Require Careful Li–Po Cells Became Possible Due To A Fine SHM-Implemented Control Algorithm. To This End, A Practical Implementation Of The Switching Battery System According To The Operating Limit Values Is Shown.

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