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Solar Unmanned Rover with Improved Mobility

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ABSTRACT

In this paper the hardware model of a charging system for batteries by means of tracking solar panels was designed. Thus the implementation of a complete energy management system applied to a robotic exploration vehicle is put forward. Is mainly brought to bring more efficiency for its working condition will be a boon for the unmanned rovers to bring out the ease of handling, will avoid the intermediate stuck in any place. The system was tested on the autonomous unmanned exploration vehicle specialized in recognition. The interest of this robotic system lies in the design concept, based on an ATMEGA8 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 to complete the process of charging a battery independently while the other battery provides all the energy consumed by the robotic vehicle. The efficiency of the panel remains same during entire day by using this intensity based solar tracking.

Keywords: $PbSO_4$ battery, photovoltaic (PV), robotic vehicle, Atmega8.

1. INTRODUCTION

In earlier days, batteries were used to provide power to the robotic system. But, the batteries when depleted could not be recharged, thus affecting the performance of the autonomous robotic system. To overcome this, fuel cell based power supply system was introduced, which replaced the batteries in portable applications. The complexity increased because of large sized fuel cells. The solar powered robotic systems are often used for many years. However, when there is scarcity of sunlight the batteries in line could not be recharged when depleted. So, rechargeable batteries came into account for the first time in the mars exploration rover. Nevertheless, the need for greater operation autonomy by spirit and opportunity was solved by means of larger deploy of solar cells. Solar power is the conversion of sunlight into electricity. Photo voltaic are used for the conversion of sunlight into electricity either directly or indirectly with (CSP), which normally concentrates the sun's energy to boil water which is then used to generate power. Photovoltaic were initially used to power small and medium sized applications, which are powered by a single solar cell to off-grid homes powered by a photovoltaic array.

Today, the declining cost and increasing efficiency of solar energy technology has given rise to practical applications on earth from powering personal devices to provide utility-scale power. Solar energy provides a huge advantage for satellites because the addition of fuel supply for satellites can be avoided while launching them into orbit. But the advantages on earth are even greater solar-generated energy provides abundant and pollution-free energy that's not dependent on fuel-delivery antecedent, foreign relations or the price machinations of energy brokers and large firm. Solar technology isn't new. Its history spans from the 7^{th}Century B.C. to today. We started out concentrating the sun's heat with glass and mirrors to light fires. Today, we have everything from solar-powered buildings to solar powered vehicles. Here you can learn more about the milestones in the historical development of solar technology, century by century, and year by year. You can also glimpse the future. Solar or photovoltaic (PV) cells are made up of materials that turn sunlight into electricity. Photovoltaic (PV) technologies including solar thermal hot water are renewable energy technologies and are clean energy alternatives compared to non-renewable energy technologies that burn fossil fuels. PV cells are composed of layers of semiconductors such as silicon. Energy is created when photons of light from the sun strike a solar cell and are absorbed within the semiconductor material.

This excites the semiconductor's electrons, causing the electrons to flow, and creating a usable electric current. The current flows in one direction and thus the electricity generated is termed direct current (DC).Once the layers have been joined, there is a negative charge in the p-layer and a positive charge in the n-layer section of the junction. This imbalance in the charge of the two layers at the p-n

junction produces an electric field between the p-layer and the n-layer.

If the PV cell is placed in the sun, radiant energy strikes the electrons in the p-n junction and energizes them, knocking them free of their atoms. These electrons are attracted to the positive charge in the n-layer and are repelled by the negative charge in the p-layer. A wire can be attached from the p-layer to the n-layer to form a circuit. As the free electrons are pushed into the n-layer by the radiant energy, they repel each other. The wire provides a path for the electrons to flow away from each other. This flow of electrons is an electric current that we can observe. About 45% of the cost of a solar cell is for the silicon wafers and about 35% is for the other components.

The amount of solar energy that strikes the Earth's surface per year is about 29,000 times greater than all the energy used in the United States in 1995.The current and power outputs of photovoltaic modules are approximately proportional to sunlight intensity.

At a given intensity, a module's output current and operating voltages are determined by the characteristics of the load. If that load is a battery, the battery's internal resistance will dictate the module's operating voltage. A module which is rated at 17 volts will put out less than its rated power when used in a battery system. This is because the working voltage will be between 12 and 15 volts. As wattage (power) is the product of volts time's amps, the module output will be reduced. For example: a 50 watt module working at 13.0 volts will produce 39.0 this is important to remember when sizing a PV system. I-V curve as illustrated to the right is simply all of a module's possible operating points, (voltage/current combinations) at a given cell temperature and light intensity. Increases in cell temperature increase current slightly, but drastically decrease voltage.

1.1 TILT ANGLE:

To capture the maximum amount of solar radiation over a year, the solar array should be tilted at an angle approximately equal to a site's latitude, and facing within 15º of due south. To optimize winter performance, the solar array can be tilted 15º more than the latitude angle, and to optimize summer performance, 15º less than the latitude angle. At any given instant, the array will output maximum available power when pointed directly at the sun.

To compare the energy output of your array to the optimum value, you will need to know the site's latitude, and the actual tilt angle of your array-which may be the slope of your roof if your array is flush-mounted. If your solar array tilt is within 15º of the latitude angle, you can expect a reduction of 5% or less in your system's annual energy production. If your solar array tilt is greater than 15º off the latitude angle, the reduction in your system's annual energy production may fall by as much as 15% from its peak available value. During winter months at higher latitudes, the reduction will be greater. Here is a short run-through of how lead-acid batteries work. I'll start with some basics and work my way up - hence the absence of an alphabetical order. Depending on your familiarity with the subject, you may want to scroll down more or less. Voltage is an electrical measure which describes the potential to do work. The higher the voltage the greater its risk to you and your health. Systems that use voltages below 50V are considered low-voltage and are not governed by an as strict (some might say arcane) set of rules as high-voltage systems. Current is a measure of how many electrons are flowing through a conductor. Current is usually measured in amperes (A). Current flow over time is defined as ampere-hours (a.k.a. amp-hours or Ah), a product of the average current and the amount of time it flowed. Power is the product of voltage and current and is measured in Watts. Power over time is usually defined in Watt-hours (Wh), the product of the average number of watts and time. Your energy utility usually bills you per kilowatt-hour (kWh), which is 1,000 watt-hours. A lead-acid battery is an electrical storage device that uses a reversible chemical reaction to store energy. It uses a combination of lead plates or grids and an electrolyte consisting of a diluted sulphuric acid to convert electrical energy into potential chemical energy and back again. The electrolyte of lead-acid batteries is hazardous to your health and may produce burns and other permanent damage if you come into contact with it. Batteries are typically built for specific purposes and they differ in construction accordingly. Broadly speaking, there are two applications that manufacturers build their batteries for: Starting and Deep Cycle. As the name implies, Starter Batteries are meant to get combustion engines going. They have many thin lead plates which allow them to discharge a lot of energy very quickly for a short amount of time. However, they do not tolerate being discharged deeply, as the thin lead plates needed for starter currents degrade quickly under deep discharge and re-charging cycles. Most starter batteries will only tolerate being completely discharged a few times before being irreversibly damaged.

Deep Cycle batteries have thicker lead plates that make them tolerate deep discharges better. They cannot dispense charge as quickly as a starter battery but can also be used to start combustion engines. You

would simply need a bigger deep-cycle battery than if you had used a dedicated starter type battery instead. The thicker the lead plates, the longer the life span, all things being equal. Battery weight is a simple indicator for the thickness of the lead plates used in a battery. The heavier a battery for a given group size, the thicker the plates, and the better the battery will tolerate deep discharges.

Some "Marine" batteries are sold as dual-purpose batteries for starter and deep cycle applications. However, the thin plates required for starting purposes inherently compromise deep-cycle performance. Thus, such batteries should not be cycled deeply and should be avoided for deep-cycle applications unless space/weight constraints dictate otherwise.

2. EXISTING METHOD

The fuel cell based power system for mobile robot. The fuel system includes a fuel stack which converts fuel into electric power. It also includes fuel for the fuel cell stack and a controller which controls the operation of the fuel cell system. The fuel system acts as an interface to the portable computing device and a bidirectional communication between the portable computing device and the controller for the fuel cell system. The fuel based power supply system increases the run time with simple refuelling. Thus the need for lengthy recharge is avoided. The power for the robotic system remains available as long as fuel is available. But, the fuel cells were large and extremely expensive to manufacture. But, just like these products the cost of fuel cells will quickly come down to consumer-affordable levels with mass production. We are currently in an evolution period now, where many fuel cell companies are investigating literally hundreds of millions of dollars to gear up for mass manufacturing at the same time they are trying to develop a variety of markets for their products.

Currently there is no hydrogen infrastructure to supply coast-to-coast delivery of hydrogen fuels. Technologies are being developed for alternative fuel storage and delivery methods. But those technologies can lower the overall efficiency of the fuel cell by ¼ and release a small amount of pollutants. Unlike standard robots and machines, whose contrivance and drive systems rapidly become very complex as the number of degrees of freedom increases, groups of Dielectric Elastomer artificial muscles have the potential to generate rich motions combining many translational and rotational degrees of freedom.

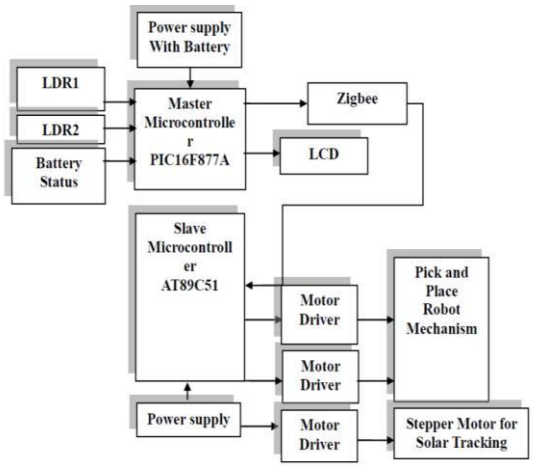


Fig 1.1 Solar powered device

A Solar Power System for experimental unmanned aerial vehicle (UAV) is designed and summarized. A microcontroller based controller was developed to collect the output power data of power source to be send to the ground station. Solar cells should not be bended, so the surface should be smooth enough for installing solar cells on the surface of the wing, an airfoil. This airfoil should also be a low-Reynolds-number airfoil.

The Dielectric Elastomer Generator (DEG) with Self Priming Circuit (SPC) can able to convert even a small microbial organism into electricity. In addition, they have the ability to produce electricity from displacement. But departing from the high stiffness algorithm of electromagnetic motors and gearboxes leads to new control challenges, and for soft machines to be truly nimble like their biological analogues, they need precise control. For an autonomous robot such as EcoBot, a good supply of electrical energy at high voltage would enable the more general use of DEA for on-board systems and there are a number of applications that DEA could be applied to. The main drawback of this system is that the time and complexity increases.

Battery charging optimization with steerable solar cells has been proposed to estimate the battery lifetime and power cost of shallow water networks in terms of four independent parameters intern-node distance, transmission frequency, frequency of data updates and number of nodes per cluster. A steerable solar panel array would track the sun as it moved across the sky, but we are not aware of any economically available domestic units in this country. Steerable arrays are costly. They need to be strong enough to resist high winds and require an adequate foundation. Solar energy also has the plausible to be

the major energy supply in the fourth coming. Solar tracker is an automated solar panel that actually follows the Sun to increase the power. Automatic Solar Tracker Robot (STR) which is capable to track maximum light intensity was designed and developed. The efficiency of the solar energy conversion can be optimized by receiving maximum light on the solar panel. The servo motor that is used to maintain the panels position in accordance with the suns position is quite complex and provides faster rotation, proposed fixed solar cells module to energize White LED light sources that are operated by directly connected White LED with current limiting resistors, which increases the power consumption.

3. PROPOSED METHOD

The design is based on the two fold contribution. First one is to charge the battery independently while another battery is discharging. The second one is to vary the panel position based on its intensity.

The intensity based panel rotation is made directly from the panel surface by the timer operation with three predefined angles set already using Atmel micro controller. The battery charging independently is totally based on the zero voltage position at the output of the battery discharge point. Their function is connecting electrically the charge and discharge paths between the batteries, the charger module, and the load system. Thus one of the batteries receives the charge current from the PV system while the other provides rover with all the energy it requires. Unlike other designs, in a conventional system the power source is used to recharge a single battery.

From this we are going to develop this technology in all kind of unmanned vehicles as well as manned vehicles. This brings the better usage of the batteries with the simultaneous charging and discharging of those which are done using the microcontrollers. The simulation part of the intensity based solar tracking and the layout design of the switching of batteries was designed in this proposed method.

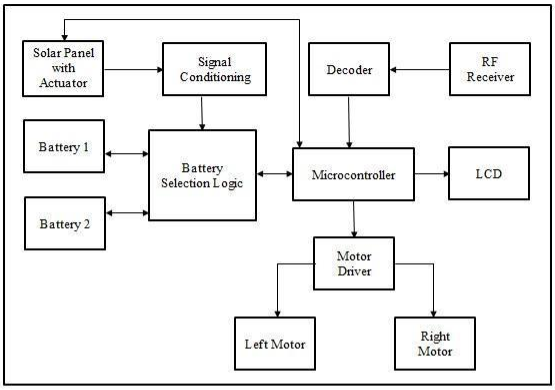


Figure 4.1 Block diagram of battery switching and solar tracking

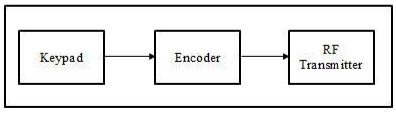


Figure 4.2 Block diagram of remote transmitter

Fig 1.2 Block Diagram of Solar Rover

4. WORKING METHODOLOGY

Solar energy radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal electricity, solar architecture and photosynthesis. A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module.The input power for efficiency calculations is 1 kW/m^2 or 100 mW/cm^2. Thus the input power for a 100 × 100 mm^2 cell is 10 W and for a 156 × 156 mm^2 cell is 24.3 WA single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and or solar and interconnection wiring. Nowadays, Solar panels are widely used for charging the batteries. Here, we are using the solar panel for charging the battery of a Robot. The main feature of this robot is the optimized solar charging. The robot itself rotates the panel to a prefixed angle with the help of a servo motor in order to find the angle in which the maximum energy can be obtained. After

determining the angle, the robots fix the position of the panel automatically.

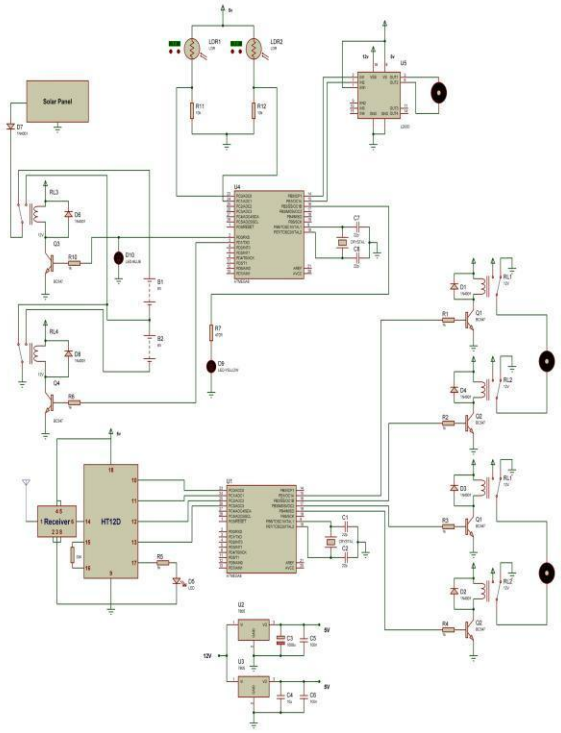


Fig 1.3 Circuit diagram for solar powered rover

Further, this robot is equipped with 2 batteries. The robot switches to the battery which has more charge. In this time the other battery starts charging via solar panel. This intelligence can be achieved by the use of a microcontroller.

4.1 HARDWARE AND SOFTWARE DETAILS

HARDWARE DETAILS

- ATMEGA8 MICROCONTROLLER
- 7SEGMENT DISPLAY (LCD)
- STEPPER MOTOR
- RECHARGEABLE BATTERY
- SOLAR PANEL

ATMEGA8 MICROCONTROLLER

The Atmel AVR ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1MIPS per MHz, allowing the system designed to optimize power consumption versus processing speed.ATmega16 has 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 Bytes. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000 respectively.ATmega16 is a 40 pin microcontroller.

The ATmega8 provides the following features: 8 Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes of EEPROM, 1 Kbyte of SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two wire Serial Interface, a 6-channel ADC with 10-bit accuracy, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM Timer/Counters, SPI port, and interrupt system to continue functioning. The Power down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next Interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions.

In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. The device is manufactured using Atmel's high density non-volatile memory technology. The Flash Program memory can be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash Section will continue to run while the Application Flash Section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega8 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

FEATURES

• High-performance, Low-power Atmel AVR 8-bit Microcontroller

• Advanced RISC Architecture

130 Powerful Instructions – Most Single-clock Cycle Execution

32 × 8 General Purpose Working Registers

Fully Static Operation

Up to 16MIPS Throughput at 16MHz

On-chip 2-cycle Multiplier

• High Endurance Non-volatile Memory segments

8Kbytes of In-System Self-programmable Flash program memory

512Bytes EEPROM

1Kbyte Internal SRAM

Write/Erase Cycles: 10,000 Flash/100,000 EEPROM

Data retention: 20 years at 85°C/100 years at 25°C(1)

Optional Boot Code Section with Independent Lock Bits

In-System Programming by On-chip Boot

Program True Read-While-Write Operation

Programming Lock for Software Security

• Peripheral Features

Two 8-bit Timer/Counters with Separate Prescaler, one Compare Mode

One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode

Real Time Counter with Separate Oscillator

Three PWM Channels

8-channel ADC in TQFP and QFN/MLF

package Eight Channels 10-bit Accuracy

Programmable Serial USART

Master/Slave SPI Serial Interface

Programmable Watchdog Timer with Separate On-chip Oscillator

On-chip Analog Comparator

• Special Microcontroller Features

Power-on Reset and Programmable Brown-out Detection

Internal Calibrated RC Oscillator

External and Internal Interrupt Sources

RELAY

Relays are electro magnetically operated switches. An actuating current on a coil operates one or more galvanically separated contacts or load circuits. The electro mechanical relay is a remote controlled switch capable of switching multiple circuits, either individually, simultaneously, or in sequence. The galvanic separation of the primary or actuating circuit and the load circuits. Single input/multiple output capability. Separation of AC and DC circuits Interface between electronic and power circuits. Multiple switching functions, e.g. delay, signal conditioning Amplifier function. Typical applications for relays include laboratory instruments, telecommunication systems, computer interfaces, domestic appliances, air conditioning and heating, automotive electrics, traffic control, lighting control, building control, electric power control, business machines, control of motors and solenoids, tooling machines, production and test equipment.

STEPPER MOTOR

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation. Every rotation of the stepper motor is divided into a discrete number of steps, and the motor must receive a separate pulse for each step.

The size of each step is same and the stepper motor can only take one step at a time. Since each pulse causes the motor to rotate a precise angle, typically 1.8°, the motor's position can controlled without any feedback mechanism. The speed of rotation is directly proportional to the frequency of the pulses.

RECHARGEABLE BATTERY

A lead acid battery is a secondary cell, meaning that it is rechargeable. It is very common in cars and trucks. It contains plates of lead and leadoxide in a sulfuric acid solution. The leadoxide oxidizes the lead plate, making an electrical current. They are the cheapest rechargeable batteries and can produce much power. They contain toxic lead, though, and should be recycled. Sealed lead acid batteries are batteries where the sulfuric acid is in a gel, preventing it from spilling out when the battery is turned up side down.

Specific energy 30–40 Wh/kg

Energy density 60–75 Wh/l

Specific power 180 W/kg

Charge/discharge efficiency 50%–92% [1]

Self-discharge rate 3–20%/month [3]

Cycle durability 500–800 cycles

Nominal cell voltage 2.105 V

SOLAR PANEL

A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar module can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module.

A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and or solar tracker and interconnection wiring.

4.2 SOFTWARE DETAILS

AVR STUDIO

AVR Studio was created by Atmel in order to help developers to create applications for AVR microcontrollers using C/C++ programming languages. This piece of software comes with a large number of tutorials, which allow the users to get familiar with the application. The program stands as a complete pack for programmers that use C++ and other programming languages. The menu of this application is easy-to-use and offers access to powerful tools for both beginners and experienced developers, making it easy for the users to find their way through C/C++ programming. Some of the key features are: ―cycle correct‖ simulator with advanced debugging functionality, rich SDK that enables tight integration of customer plug-ins and compatibility with many Microsoft Visual Studio plug-ins. Also the tool provides a "split window" button that allows the users to work on more than one project at a time.

AVR STUDIO FEATURES

- It is a full software development environment with an editor, simulator, programmer, etc.
- It comes with its own integrated C compiler the AVR GNU C Compiler (GCC). As such you do not need a third party C compiler.
- Provides support for several programmers including the STK500, AVR Dragon, etc.

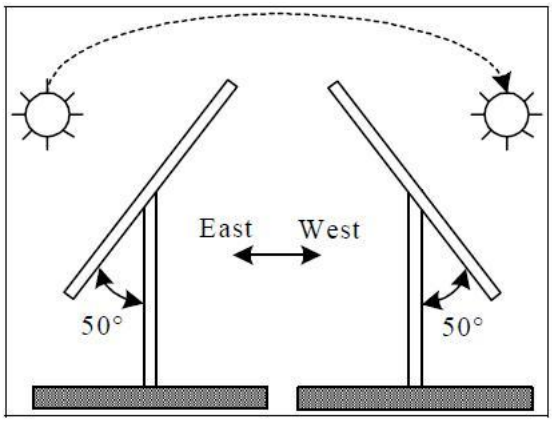
AVR STUDIO 5

AVR Studio 5 is a software development environment produced by Atmel for its AVR 8-bits and 32-bits family of AVR microcontroller. Atmel AVR Studio 5 is the Integrated Development Environment (IDE) for developing and debugging embedded Atmel AVR applications, and gives you a seamless and easy-to-use environment to write, build, and debug your C/C++ and assembler code. The front-end visualize for all of the Atmel AVR programmers and in-circuit debuggers.

AVRs have been used in various automotive applications such as security, safety, power train and entertainment systems. Atmel has recently launched a new publication "Atmel Automotive Compilation" to help developers with automotive applications. Some current usages are in BMW, Daimler-Chrysler and TRW.The Arduino physical computing platform is based on an ATmega328 microcontroller.

The ATmega1280 and ATmega2560, with more pin out and memory capabilities have also been employed to develop the Arduino Mega platform. Arduino boards can be used with its language and IDE, or with more conventional programming environments (C, assembler, etc.) as just standardized and widely available AVR platforms. USB-based AVRs have been used in the Microsoft Xbox hand controllers. The link between the controllers and Xbox is USB.

ALGORITHM FOR INTENSITY BASED SOLAR TRACKING:



Step 1: Get the output voltages of two light dependent resistors.

Step 2: Compare all the two voltages.

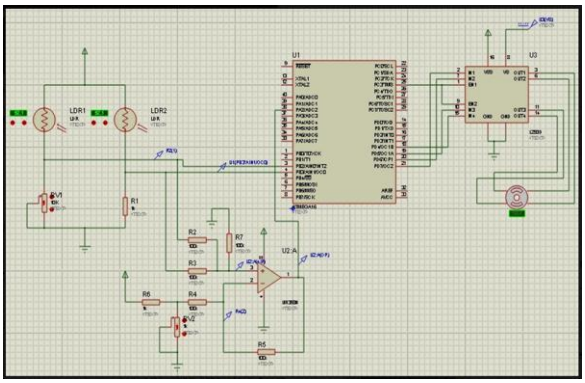
Step 3: Predefine the motor rotation to all the LDR output as left, right and centre rotation.

Step 4: As the result of highest possible output the controller sends control signal to the motor as it rotates to the prescribed direction.

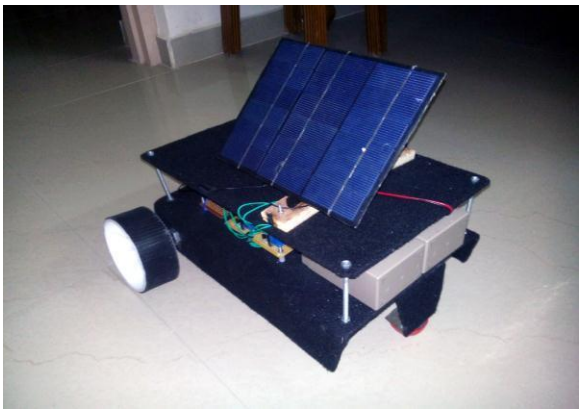
5. RESULTS AND DISCUSSION

In the previous review, the block diagram of proposed method was designed. Also the advantage that overcomes the existing method was explained. The solar panel tracking for its varying angles corresponding to its intensity with the programming in Atmel microcontroller was designed. By using the battery switching layout and the solar tracking mechanism the mobility of the unmanned solar rover increased, the software implementation of the solar tracking mechanism and the layout for battery switching was designed using AVR studio and proteus software. 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.

5.1 SOFTWARE RESULTS



5.2 HARDWARE MODEL



5.3 CONCLUSIONS AND FUTURE WORK

The interest of this robotic system lies in the design concept, based on microcontroller. On this basis, our proposal presents the construction of a solar tracking mechanism aimed at increasing the rover's power regardless of its mobility. The battery switching and intensity based solar unmanned rover was designed and constructed. This project has presented a smart energy management system applied

to a robotic platform, 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. 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.

FUTURE WORK:

The future design includes the advancement in the circuit size, low power consumption and improving the efficiency. The design can be implemented in any form of unmanned vehicles for research purpose. This can be implemented in agricultural robotics and other unmanned vehicles. The mechatronics design of the rover can be improved in future work.

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