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Research Paper

SMART HOST MICROCONTROLLER BASED SOLAR POWERED TOOL WITH ROBOTIC ARM

P Sathya Priya[1], P Rathi[1] and R Anusuya Devi[1]*

*Corresponding Author: **R Anusuya Devi,** ✉ anusuya.ece5@gmail.com

Robotic technologies deal with automated machines that can take the place of humans, hazardous or manufacturing processes, or simply just resemble humans. A robotic arm is a type of mechanical arm usually programmable with similar functions to a human arm; the arm may be sum of the mechanism or may be a part of more complex robot. Solar energy is a radiant light and heat from the sun has been harnessed by humans since ancient times using a range of ever-evolving technologies. This paper aims to design and construct a robotic vehicle which is powered by solar energy with robotic arms to pick and place an object. In existing method, the solar powered robotic vehicle was designed and is used for increasing the vehicles power by means of solar energy. The proposed system introduces a robotic arm to the vehicle to pick and place an object. There are two ways to charge the vehicle. One method of charging is through direct power supply and alternative method is tracking solar energy. Thus the complete solar energy is utilized by the robotic vehicle to perform pick and place operation using robotic arm was fulfilled.

Keywords: Li-po battery, Solar tracker, Robotic tool, Pick and place mechanism, Photovoltaic (PV)

INTRODUCTION

Robot is an electro-mechanical machine which was guided by an electronic circuit. It can be autonomous, semi autonomous or remotely controlled. The branch of technology that deals with robot is called Robotics. The use of robots in military combat raises ethical concerns. Industrial robots usually consist of a jointed arm and end effectors that is attached to fixed surface. In 2003, NASA's Mars Exploration Rovers will launch towards Mars in search of answers about the history of water on Mars. Robotic manipulators used in manufacturing are examples of fixed robots. They cannot move their base away from the work being done. Mobile bases are typical platforms with wheels or tracks attached. Instead of wheels, some robots employ legs in order to move about.

[1] Faculty of Engineering, University Malaysia Sarawak (UNIMAS), Kota Samarahan 94300, Sarawak, Malaysia.

Solar energy is the best renewable resource which can generate electricity. The photovoltaic cells used in calculators and satellites are responsible for converting sunlight directly into electricity. This cell is made up of semiconducting materials such as silicon. Basically, when light strikes the semiconductor it is absorbed and then allows the electron energy to flow freely. The main function of PV cells is it converts the phonons to electrons. An atom of sili-con has 14 electrons, arranged in three different shells. Silicon has the pure crystalline form. When energy is added to pure silicon, as in the form of heat for example, it can cause a few electrons to break the bonds and leave their atoms. This process produces electric current in p-n junction. Two separate pieces of silicon were electrically neutral and to reduce losses in the electric field produced in the silicon antireflective coating is applied to those surfaces. This solar energy can also be used for the function of robot. Robots used in military purpose gain energy from solar will be useful for complete energy utilization. This can be done by using solar tracking mechanism.

Real example for this type of solar powered robotic vehicle is VANTER robot which was tested on an unmanned exploration robotic platform (Tomas de *et al.*, 2012). The electrical energy applied to artificial muscles is converted to mechanical energy using Dielectric Elastomeric Actuators (DEA) (Anderson *et al.*, 2011). In solar tracker robot, the microcontroller PIC16F877A is used to track maximum light intensity. However, MPLAB IDE v8.30 is used for the programming of robot. For the conversion of solar power Fluke 1750 power quality recorder is used (Afarulrazi *et al.*, 2011). In robotic application, to provide flexibility the combination of compliant actuation and light weight mechanical design Bio-rob robot arm was designed (Bartolomeo *et al.*, 2010). An ultrathin film silicon cells are constructed on carbon fiber reinforced plastic which gives higher power and efficiency for the future exo mars mission (Gonz´alez, 2010). A solar tracker is a device which orients various payloads towards the sun to increase the amount of energy produced by the fixed amount of power generating capacity (Lee *et al.*, 2009). The vehicles used to explore the Martian surface require a high degree of autonomy to navigate and detect scientific events (Bajracharya *et al.*, 2008). A hybrid robotic wheel chair is generated using solar cells and fuel cells so that complete energy can be utilized (Takahashi *et al.*, 2008). The monolithic electro thermal micro grippers are used to demonstrate pick and place operation (Anderson and Carlson, 2008). The use of conventional lead acid battery was converted to a hydrogen fuelled polymer electrolyte membrane which is used as a power source in mobile robots (Wilhelm *et al.*, 2006).

The solar powered tool with robotic arm aims to operate the robot by solar energy for complete energy utilization. By this concept the robotic vehicle can be operated without any power supply, it can automatically generate the electricity which is completely utilized by the robot itself. The main advantage of this method is that there is no loss of energy and the pick and place operation of the robotic vehicle can be used mainly for military purpose for bomb removal. The robot is operated by the smart host microcontroller which implies that it can

take decisions by its own through imbuilded coding. The following sections explains about the components used in project and how they are related to the project.

SYSTEM REQUIREMENTS AND TECHNICAL BACKGROUND

Microcontrollers and zigbee transceiver operations where explained in this section. The major functions are performed by these components which are explained below:

8051 Microcontroller

The generic 8051 microcontroller has the architecture which supports Harvard Architecture which contains two separate buses for both data and program. It has two distinctive memory spaces of 64 K x 8 size for both program and data. It is based on 8 bit central processing unit with an 8 bit Accumulator and another 8 bit B register as main processing blocks. Other portion of the architecture includes few 8 bit and 16 bit registers and 8 bit memory locations. All 8031 device has some amount of data RAM built in the device for internal processing. This area is used to perform stack operations and temporary storage of data. The base architecture is supported with on chip peripheral functions like I/O ports, timers/counters and versatile serial communication port. So it is clear that 8051 architecture was designed to create many real time embedded needs.

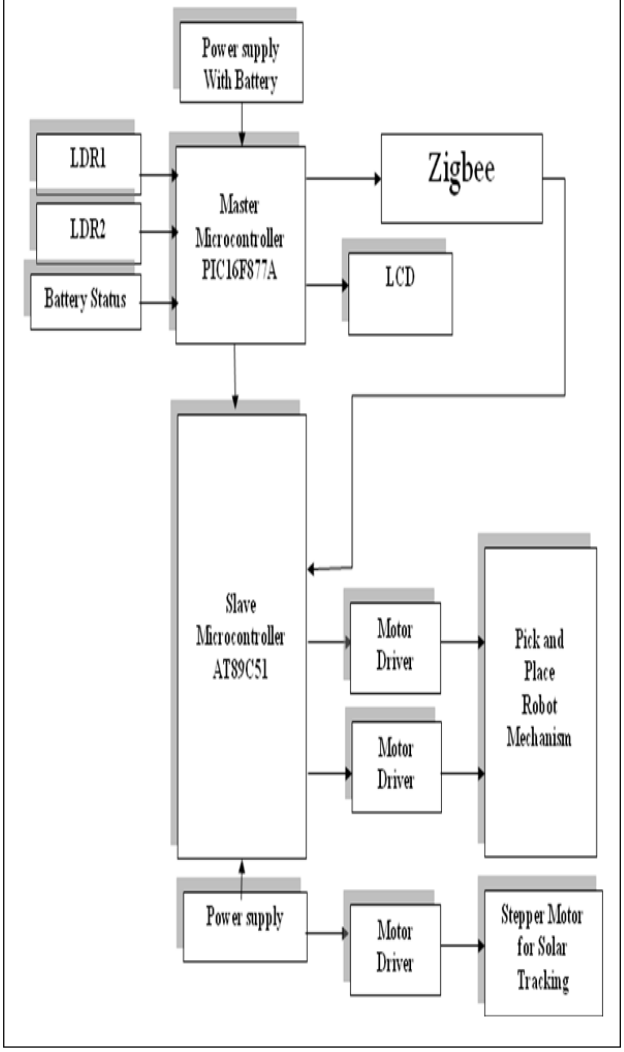
8051 microcontroller acts as a slave microcontroller which performs various functions. The stepper motor operation is performed by this slave microcontroller. One method of charging the battery is done through 8051 microcontroller which is the direct power supply. The solar panel's direction is adjusted according to the direction of sunlight using 8051. The solar tracking mechanism is also connected with the slave microcontroller. The overall function of 8051 microcontroller is it performs the Driving functions.

PIC Microcontroller

PIC refers to peripheral interface controller. It belongs to the family of modified Harvard architecture microcontroller which was made by microchip technology. It is more popular due to their low cost, wide availability, free development tools and reprogramming (serial programming) in flash memory.

The zigbee 2007 is the general standard for wireless monitoring and control applications. The 2007 version supports two profiles. Zigbee (stack profile 1) targets consumer products in the home and light commercial environments. It is designed for simpler, plug and forgets networks that are typically less than 300 nodes. Zigbee pro targets commercial and industrial environments. It has thousands of nodes, more complex network that requires higher level of expertise, security and commissioning. Zigbee RF4CE standard is targeted to have a simple, robust remote control network used in consumer applications. A zigbee network stack is built upon the IEEE 802.15.4 standard and it adds upper level services. The application interface to the standard stack through an Application Interface (API). There are also the marketing benefits of a public certification process, leveraged marketing awareness and branding via the zigbee alliance.

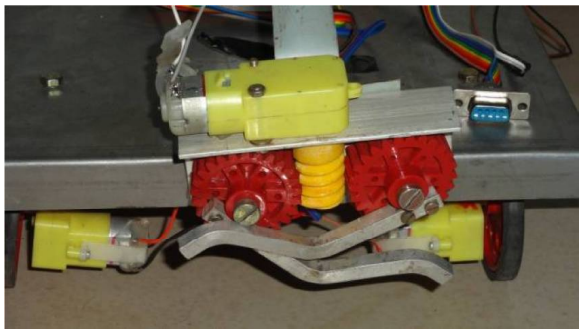
Figure 1: Block Diagram of Pick and Place Mechanism and Solar Tracking Operation



The original PIC was built with 16 bit CPU and the CP1600. The CPU was good, but CP1600 has poor I/O performance. Eight bit PIC was developed to improve the performance of overall system by offloading I/O tasks from the CPU. Microcode was stored in ROM to perform the tasks. But the term was not used, it shares the common features with RISC design the PIC microcontroller was upgraded with micro-electronics and EPROM. But now the PIC's are available with serial communication modules and program memory from 256 words to 64k words. PIC 16 x 84 is the first microchip with on-chip EEPROM memory. It is an electrically erasable memory and its cost is low compared to other memories.

PIC is used as the master microcontroller to sense the intensity of light. PIC microcontroller is used as master because of its high performance ability.

Figure 2: Pick and Place Robotic Arm



Nowadays, PIC microcontrollers are mostly preferred by the embedded projects. The PIC16F877A is used to sense the light intensity from two different directions using Light Dependent Resistors (LDR) using the solar panels. The latest version A PIC microcontroller is shown in Figure 3.

Figure 3: PIC16F877A

ZIGBEE

Zigbee wireless protocol standards are intended to provide monitoring, control and sensory network services in a cost-effective manner. Zigbee is a mesh network which is used for high transmission data rates using low protocols or digital radios. The advantage of using Zigbee is that it has low data rate, low power consumption, security and reliable operations. The standards are the communication stacks which are built on top of the IEEE 802.15.4 MAC/PHY standard. It supports two basic specifications. They are zigbee 2007 and zigbee RF4CE.

The zigbee 2007 is the general standard for wireless monitoring and control applications. The 2007 version supports two profiles. Zigbee (stack profile 1) targets consumer products in the home and light commercial environments. It is designed for simpler, plug and forgets networks that are typically less than 300 nodes. Zigbee pro targets commercial and industrial environments. It has thousands of nodes, more complex network that requires higher level of expertise, security and commissioning. Zigbee RF4CE standard is targeted to have a simple, robust remote control network used in consumer applications. A zigbee network stack is built upon the IEEE 802.15.4 standard and it adds upper level services. The application interface to the standard stack through an Application Interface (API). There are also the marketing benefits of a public certification process, leveraged marketing awareness and branding via the zigbee alliance.

The zigbee network solution preserves many of the advantages of the 802.15.4 standard. The robot designed here is controlled using Zigbee protocol. The Battery status will be continuously measured and sent back to the monitoring unit through Zigbee. The monitoring section consist of a PC with Zigbee transceiver, VB based user interface used to control the unmanned exploration vehicle. Since we are using solar-based system, power consumption is reduced.

OVERVIEW

Solar power system is used to operate the robot is the main focus of this project and the function of robotic vehicle is used to perform another operation that is to pick and place any objects. There are two sections in this operation. One is the transmitter part and another section is the receiver section. The receiver section consists of the zigbee transceiver and 8051 microcontroller and the transmitter section consist of solar panel, PIC microcontroller and pick and place robotic arm.

RECEIVER

Control and monitoring functions are performed by the receiver part. This part consists of 8051 microcontroller and Zigbee transceiver. The 8051 microcontroller's main function is driving function. The solar panels direction is adjusted according to the sunlight direction using this 8051 microcontroller. The stepper motor operation is to drive the robotic vehicle wheels. It makes wheels of the robotic vehicle to rotate using the coding that are implemented in the microcontroller itself. One way of charging the battery is the direct power supply which is connected with the transmitter part. The direct power supply is given to the step down transformer which is placed in the

receiver part. This direct power supply is converted into 5 V as the input of robotic vehicle. The voltage comparator is used to regulate the voltage. Bridge rectifiers are also used to convert the voltage from higher level to lower level. Reset button is fixed in the receiver which is used to re-execute the program if any interruption is happened during the program execution. This prevents the circuit from any interruption and makes the pick and place operation of the robotic vehicle. A crystal oscillator is used in the receiver part to continuously produce the oscillated signals.

The zigbee transceiver is the next part of the receiver which performs the monitoring functions. The battery status is measured continuously and it is sent back to the microcontroller using the zigbee. The monitoring section used here is LCD display and the PC which was useful to measure the battery status. Four relays are used in the receiver section. Each relay performs a different operation for the forward, backward, left and right movement of the robot. For each movement the relay light will be turned ON and OFF. The block diagram for the overall project is shown below. MAX 232 is used to connect the zigbee and PC as an interface between the transmitter and receiver. It is mainly used to convert the serial to parallel communication.

The receiver part has the operation of slave microcontroller. It can performs the driving functions.

TRANSMITTER

Solar tracking mechanism and PIC microcontroller operations are carried out in the transmitter section. PIC microcontroller is interconnected with the 8051 microcontroller. PIC is used as a master microcontroller which is used to sense the intensity of the light using Light Dependent Resistors (LDR). The solar tracking mechanism is also in the transmitter part which converts the solar energy into electrical energy. This electrical energy can be stored in the Li-Po battery which is nothing but lithium polymer batteries. The robotic vehicle is four wheeled. The electrical energy is then given to the stepper motor which is used to change the direction of solar panel from the instruction given from receiver side. A DC motor is also used in the receiver part. The main function of DC motor is, it is used to rotate

Figure 4: Zigbee Transceiver in Receiver Side

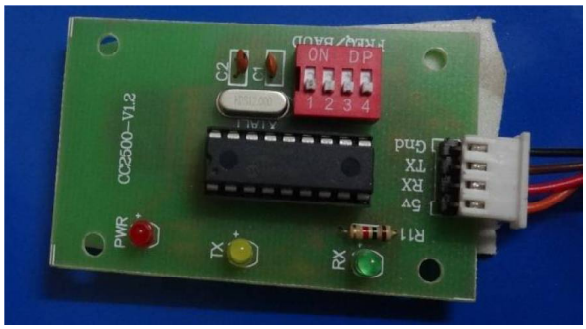
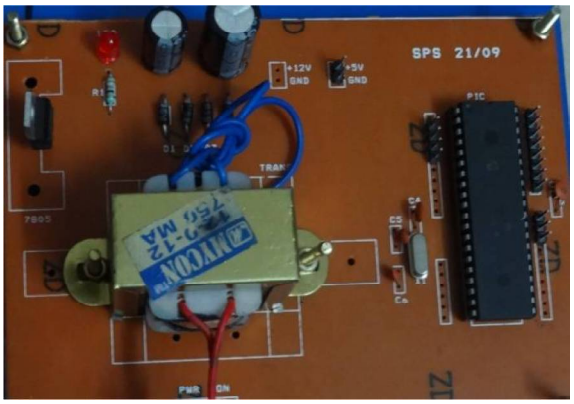


Figure 5: PIC Microcontroller in Transmitter Section



the wheel of the robot and also for pick and place operation in the robotic vehicle.

The solar tracking mechanism is placed in the receiver section. The stepper is used to change the direction of solar panel according to the sunlight direction. The receiver section also has the zigbee transceiver which is used to operate the robot according to the commands given from the transmitter using Hyper Terminal software.

Figure 6: Transmitter Section with Zigbee and MAX232 Port

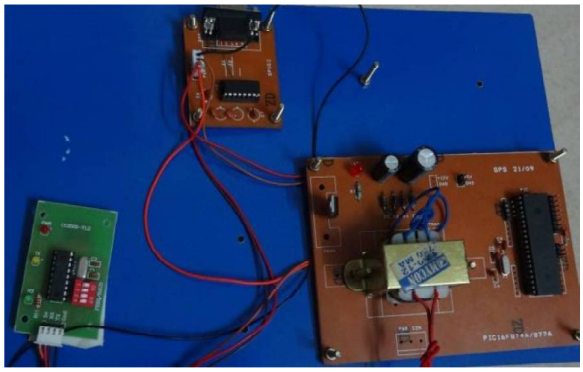
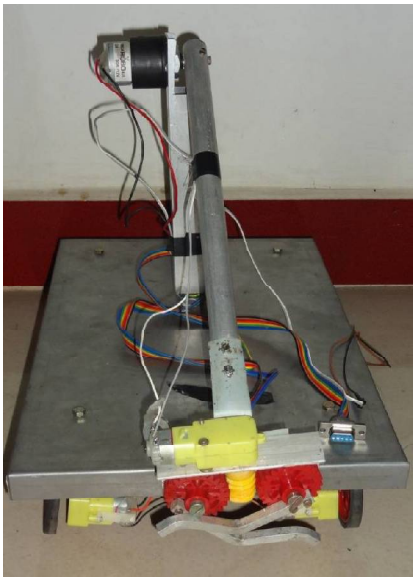


Figure 7: Robotic Vehicle with Pick and Place Arm



CONCLUSION

The Smart Energy Management system based solar powered robotic vehicle with a robotic arm to pick and place objects was implemented. The complete energy can be utilized by the robot by the use of solar energy is the main advantage of this paper. The pick and place operation of the robotic arm was also performed by the energy gained from the solar tracking mechanism. This robotic vehicle can be used for military purpose to pick and place bomb. Therefore, the purpose of this robot will be very effective for the future instead of using human for battle, robots can be used for military purpose and the energy can be gained from the solar which is the major renewable resource. The success in the implementation of this solar powered robotic vehicle with robotic arm will be very effective in the future of robotic world.

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