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Optimal Battery Charging of Solar Powered Vehicle and Monitoring Using Labview

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Abstract: The idea proposed in this paper is to optimize the charging of the battery in solar powered vehicle and monitoring the parameters using Ultra high frequency communication by Labview. Here the vehicle is powered by solar energy which uses the solar power effectively. It optimizes the charging of the battery through two ways. First method is tracking the solar light in order to receive the maximum voltage through light sensors. Second method is using additional battery in order to store maximum solar energy through proper relay switching operated by a microcontroller. The parameters of the vehicle are monitored in a Graphical User Interface. The GUI used here is LabVIEW. The Data from the microcontroller are sent to the LabVIEW through UHF communication. Here Zigbee technology is used for the UHF communication.

I. INTRODUCTION

The vehicle has two parts, the first part has solar panel and it's tracking system and the second part has battery management system. The solar tracking and the battery management are controlled by using PIC microcontroller 16F877A. The solar panel is 12 volt suitable to charge a 12 volt battery. The solar tracking mechanism consists of a dc gear motor and four light sensors. The light sensors used here are light dependent resistors (LDR). The solar tracking system consists of a dc gear motor which is controlled by the microcontroller to rotate in the direction of the maximum intensity of light sensed by the LDRs.

In the battery management sector there are two batteries. One battery is used for charging and another is used for discharging purpose at any instant. It consists of two battery selectors operated by the microcontroller based on the voltage in the battery. Battery selector 1 connects solar panel and one battery, while the other connects the battery with the load. Here load is the motor that drives the vehicle, traction motor and other circuit components.

The entire circuit is controlled by PIC microcontroller 16F877A. The microcontroller is programmed to detect the maximum intensity of light through LDR in all four directions and instructs the dc gear motor to rotate in the respective direction to obtain maximum voltage. It also acquires the voltage from the battery and gives pulses to the battery selector to select the battery for charging and discharging.

The vehicle parameters are being monitored by LabVIEW software. The Data transfer between the microcontroller and the LabVIEW is enhanced by the UHF communication (Zigbee technology). The Zigbee technology consists of two transceivers, connected at both terminals. The transceiver is connected to LabVIEW through RS 232 cable. The transceiver on the microcontroller side is connected via Max 232 IC. The parameters monitored in LabVIEW are LDR intensity, position of the solar panel, voltage of the batteries.

II. MODULE DESCRIPTION

A. Solar Panel

A solar cell or photovoltaic cell is a device that converts solar energy into electricity, by the photovoltaic effect. Sometimes the term solar cell is reserved for devices intended specifically to capture energy from sunlight, while the term photovoltaic cell is used when the source is unspecified. Assemblies of cells are used to make solar panel, solar modules, or photovoltaic arrays.

B. Batteries

The lead acid battery produces electrical charges through a chemical reaction. Inside the battery, plates of lead, and plates of lead oxide are fixed in a water and sulfuric acid solution. The chemicals then produce electricity that may be conveyed to wires to turn on lights and start the ignition. Electric vehicles use a traction battery, which actually takes the place of the power source for the vehicle.

C. Tracking System

The dc gear motor is used to track the sunlight based on the intensity of light and instruction from the microcontroller. The solar panel is inclined at an angle of 18 degrees to obtain maximum sunlight at all time.

D. Microcontroller

The microcontroller used in our project is 16F877A. This is chosen because it has an inbuilt ADC through which the analog inputs can be directly given. So that it converts the incoming analog inputs to its corresponding digital value and the ordinary microprocessor operation is carried out.

The microcontroller controls the entire operation of the circuits. It receives the input from the LDR and then instructs the dc gear motor regarding the direction of rotation and the time period of rotation. The controller also receives the voltage from the batteries and then switches between the batteries for charging and discharging. The controller communicates with the LabVIEW by sending all the data to it through wireless transmission.

III. DEVELOPMENT TOOLS

The Development Systems product categories are:

A. Compiler

Compiler is a computer program (or set of programs) that translates text written in a computer language (the source language) into another computer language (the target language). The original sequence is usually called the source code and the output called object code.

B. Emulator

Emulator is a device it has the ability of a computer program or electronic device to imitate another program or device.

C. In Circuit Debugger

Microchip's in-circuit debugger for the flash PIC16F87x family only utilizes the in-circuit Debugging capability of the PIC16F87X along with in-circuit Serial Programming (ICSP) protocol to provide cost-effective in-circuit flash programming and debugging from the graphical user interface of the MPLAB

IV. SENSORS AND RELAY DRIVERS

A. Sensors

A sensor (also called detector) is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or an (today mostly electronic) instrument. For accuracy, most sensors are calibrated against known standards.

A sensor is a device which receives and responds to a signal when touched. A sensor's sensitivity indicates how much the sensor's output changes when the measured quantity changes. Sensors need to be designed to have a small effect on what is measured; making the sensor smaller often improves this and may introduce other advantages. In most cases, a micro-sensor reaches a significantly a higher speed and sensitivity compared to macroscopic approaches.

B. Relay Driver

1) *Driver Circuit:* A driver circuit is an electrical circuit or other electronic component used to control another circuit or other component, such as high power transistor. They are usually used to regulate current flowing through a circuit or used to control the other factors such as other components, some devices in the circuit. Typically the driver stages of a circuit require different characteristics to other circuit stages. In our project there are three electromagnetic relay. These relays operate as electronic switches.
2) *Relay Driver Circuit*: The relay driver circuit, an electromagnetic relay acts as an electrical switch to control the various equipment according to input signal received from the microcontroller. If this signal reaches the relay then the coil gets energized and thus the circuit closes which is responsible for the conduction.

V. LEVEL CONVERTER

The MAX232 is the IC that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits and vice versa. The MAX232 is a dual driver/ receiver and typically converts the RX, TX, CTS and RTS signals.

Now that we have the 8 bit value in the 16F877A, we want to send that value to the PC. The 16F877A has a built in serial port that makes it very easy to communicate with the PC's serial port but the 16F877A outputs are 0 and 5 volts and we need +10 and -10 volts to meet the RS232 serial port standard. The easiest way to get these values is to use the MAX232. The MAX232 acts as a buffer driver for the processor. It accepts the standard digital logic values of 0 and 5 volts and converts them to the RS232 standard of +10 and -10 volts. It also helps protect the processor from possible damage from static that may come from people handling the serial port connectors.

The MAX232 requires 5 external 1uF capacitors. These are used by the internal charge pump to create +10 volts and -10 volts.

The MAX232 is an electronic circuit that converts signals from a serial port to signals suitable for usage in e.g. microprocessor circuits.

A standard serial interfacing for PC, RS232C, requires negative logic, i.e., logic '1' is -3V to -12V and logic '0' is +3V to +12V. To convert TTL logic, say, TxD and RxD pins of the microcontrollerchips thus need a converter chip. The MAX232 is a four-channel driver; it amplifies/lowers RX, TX, CTX and RTS signals. The voltage discrepancy (up to +- 12 V from RS232 to 3.3V TTL) is generated by capacitors (typically 10 nF). An MAX232 has a typical threshold of 1.3 V, a typical hysteresis of 0.5 V, and can accept ±30-V inputs. The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply TIA/EIA-232-F voltage levels from a single 5-V supply.

A. Load

The load used here is 12v dc motor. There are four dc motors which drives the vehicle. Each wheel is driven by separate motor. All the motors are supplied from a single battery. Also dc gear motor which is used for solar traction is supplied from the same battery.

B. LCD Display

The display used here is 16 x 2 alphanumeric LCD display. The LCD display is connected to port D of the microcontroller. The batteries voltages, LDR intensity values, state of the batteries are indicated.

C. Zigbee Transceivers

ZigBee and IEEE 802.15.4 are standards-based protocols that provide the network infrastructure required for wireless sensor network applications. 802.15.4 defines the physical and MAC layers, and ZigBee defines the network and application layers. For sensor network applications, key design requirements revolve around long battery life, low cost, small footprint, and mesh networking to support communication between large numbers of devices in an interoperable and multi-application environment.

There are numerous applications that are ideal for the redundant, self-configuring and self-healing capabilities of ZigBee wireless mesh networks.

The ZigBee standard was developed to address the following needs

1) Low cost
2) Secure
3) Reliable and self- healing
4) Global with use of unlicensed
5) Radio bands
6) Flexible and extendable
7) Low power consumption
8) Easy and inexpensive to deploy
9) Integrated intelligence for network
10) set-up and message routing

VI. LABVIEW

LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a fully featured programing language produced by National instruments. It is a graphical language which is quite unique in the method by which the code is constructed and saved. There is no text based code as such, but a diagrammatic view of how the data flows through the program. Thus LabVIEW is much

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easy tool for scientist and engineer who can offer visualized data flow rather than how a text based conventional programing language must be built to achieve a task.

VII. BLOCK DIAGRAM FUNCTIONING

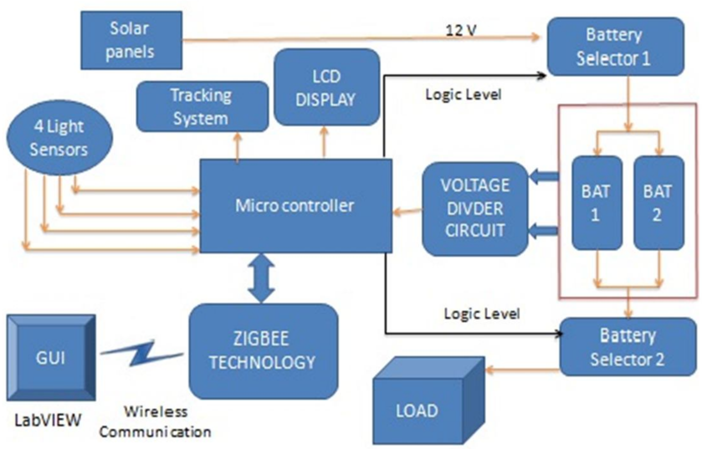

Figure 1: Block diagram-Equipment section

The solar panel charges the battery when the sun light is available. A traction mechanism is applied to capture the maximum intensity of the sunlight through a 12v DC gear motor and LDR arrangement. Four LDR are connected to ADC channels of the microcontroller. The microcontroller checks for the max intensity and rotates the 12v solar panel in the desired direction through the motor and driver circuit arrangement. The driver circuit consists of electromagnetic relays and transistors. Two 6v, 4.5AH batteries are connected in series and form a battery segment. Two such battery segments are used here. Based on the condition, battery with more charge is utilized for discharging and the other is used for charging. For this the voltages of the batteries are being fed to the microcontroller. The microcontroller switches the battery selector 1 & 2 between the batteries. The battery selector arrangement consists of relay driver circuit.

VIII. CALCULATION

A. The RPM of the DC gear motor used for the solar traction = 30rpm. The solar light is tracked on four sides. Hence the degree of rotation=360/4=90. Time for 1 full revolution=2000 ms (2s).
   Therefore time for $1/4^{th}$ revolution =500 ms (0.5s)

B. The number of bits in microcontroller for reading analog values is calculated using the following, No. of bits for 5V=1023 bits
   Analogue value for 1 bit =5/(1023) V

C. The voltage divider circuit is 40K ohms resistance in total for each battery. The voltage is divided into four and one of the four parts is given as input to the microcontroller.

D. The battery is switched at 13 V and 9 V. The no of bits for 13 V =(13/4)*(1023/5)=664 bits. Hence no of bits for 9V= (5/1023)

IX. VERIFICATION

The solar panel successfully tracked the solar light based on the above calculations. Also the battery management was successfully verified by draining the battery and charging them fully. The zigbee transceiver received the parameters successfully and it was monitored in LabVIEW.

Figure 2:Hardware Assembly 1

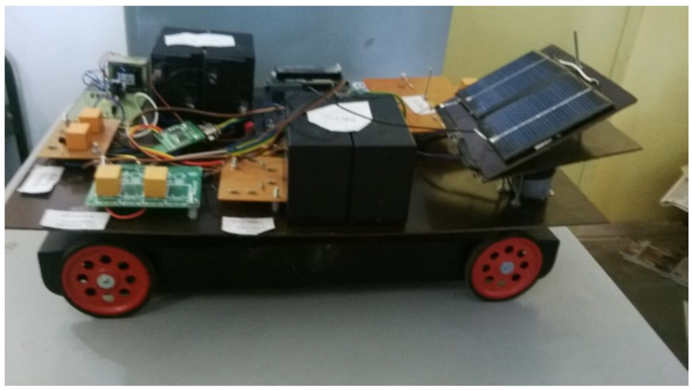

Figure 3. Hardware Assembly 2

X. CONCLUSION

Thus the solar car automatically tracked the solar light and made use of the solar energy efficiently. It also switched between the batteries for charging and discharging based on the voltage in the battery. The entire process was controlled by the microcontroller. The various parameters were monitored in the wireless control section. The acquired data from the status of the equipment section were sent wirelessly through a pair of zigbee transceivers. At the wireless control section received data was sent to the computer by means of RS232 cable and vice-versa. In this manner the monitoring of the parameters was done.

Further enhancement can be made to the project by adding a GPS module to the vehicle and the location of the vehicle can be traced and it can be sent to the monitoring station along with the co-ordinates of the position of the vehicle.

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