



Design and Development of a Low Cost Solar Automated Vehicle

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Abstract- This paper represents design and development of a low cost solar automatic vehicle with two innovative approach. In both approaches, the solar automatic vehicle will be able to move on the road turn to left or right and stop at any obstruction on the road automatically. The automation is done by using three photosensors in the first approach and by using photosensors and a microcontroller (PIC 16F877A) in the final approach. In the first approach, the photo sensors detect black or white color. Depending upon the color, the left and right photosensor will generate control instructions for the vehicle by observing the road so that the vehicle can turn left or right automatically and for any kind of obstruction found in road, the front sensor will detect it and send signal to the relay, which will stop driving the main power source to the driving unit and make the vehicle stop. In the final approach photosensors, depending upon color of the road, detect signals from the road and produce control instruction for the microcontroller. Microcontroller then process the instruction and generate instruction for the driving section. The driving section drives the vehicle according to the road.

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Design and Development of a Low Cost Solar Automated Vehicle

Rony Sorkar ^α, Zubaeer Alam ^σ & Galib Hashmi ^ρ

Abstract- This paper represents design and development of a low cost solar automatic vehicle with two innovative approach. In both approaches, the solar automatic vehicle will be able to move on the road turn to left or right and stop at any obstruction on the road automatically. The automation is done by using three photosensors in the first approach and by using photosensors and a microcontroller (PIC 16F877A) in the final approach. In the first approach, the photo sensors detects black or white color. Depending upon the color, the left and right photosensor will generates control instructions for the vehicle by observing the road so that the vehicle can turn left or right automatically and for any kind of obstruction found in road, the front sensor will detect it and send signal to the relay, which will stop driving the main power source to the driving unit and makes the vehicle stop. In the final approach photosensors, depending upon color of the road, detect signals from the road and produce control instruction for the microcontroller. Microcontroller then process the instruction and generate instruction for the driving section. The driving section drives the vehicle according to the road. For the driving section a L293D IC is used. Here 12 Volt, 10 Watt battery are used as power source and this battery is charged by a 16 Volt, 12 Watt solar panel. There is an alternative option to charge the battery of the vehicle directly from the 220 Volt AC line. The prototype car developed show promises of safe driving and hopefully one day a fully automated solar vehicle will be on the street..

Keywords: photosensors, solar automatic vehicle.

I. INTRODUCTION

Road accident is rapidly increasing with the number of vehicle and with the extension of metro life. About 1.24 million deaths occurred worldwide in the year 2010 due to road traffic injuries [1], and the number of people are injured or disabled every year also in the range of tens of millions [2]. WHO, is already working with governmental and nongovernmental organizations around the world to raise awareness to avoid road traffic injuries [2]. Many other organizations like, National Highway Traffic Safety Administration (NHTSA), USA, are on the pursuit of vehicle safety has led to focus attention on self-driving automated vehicles [3]. Already Google got, first self-driven automated vehicle license in Nevada, USA [4]. Still there is lot of

research work needed before the first low cost automated vehicle is on the road. For this purpose, this paper demonstrates design and development of a low cost solar automatic vehicle.

The demand of fuel energy is increasing day by day due to industrialization, transportation and inhabitation. According to BP (British Petroleum)- the Global demand will rise up to 5 to 20 Mb/d (Millions of Barrels per Day) from 2015 to 2035 [5]. So renewable energy (energy from a source that is not depleted when used, such as wind or solar power) is indispensable for this crises. Renewable energy has a lot of advantages over the fuel energy, which is available abundant amount in nature with no negative effect on environment, having no solid wastes. It reduces pollution production and do not threaten the atmospheric levels. For these specific reasons, renewable energy to be used. The automatic solar vehicle is powered by solar energy and it is done by incorporating the vehicle with a solar panel.

This paper discuss about design and development of an automated solar vehicle. The schematics were drawn by using Proteus Lite software and the components were soldered into veroboard. It was found that the automated solar vehicle is able to move around the road automatically by using three photosensors or using photosensors and a microcontroller (PIC 16F877A).

II. BACKGROUND STUDY

a) Automated Vehicle

Automated Vehicle is a vehicle, which has at least one automated functions (like steering, acceleration etc.). According to National Highway Traffic Safety Administration (NHTSA), USA. At level 4, an automated vehicle will be able drive itself without a human driver [6]. The main reason for using automated vehicle is that, this technology will reduce crashes. Moreover, there will be less power consumption and pollution.

b) Solar Module / Panel

When groups of solar cells are interconnected and mounted together it is called solar panel or module. Like, a 12 V single solar module (panel) will contain 36 cells connected in series in a sealed weatherproof package [7]. Each solar cell in a solar module converts light energy to electricity, so that the solar panel can be used as a power source. Because solar energy is

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available in abundance and considered the easiest and cleanest means of tapping renewable energy[8], solar

panel is used in the design as a mean of charging the battery of automated solar vehicle.

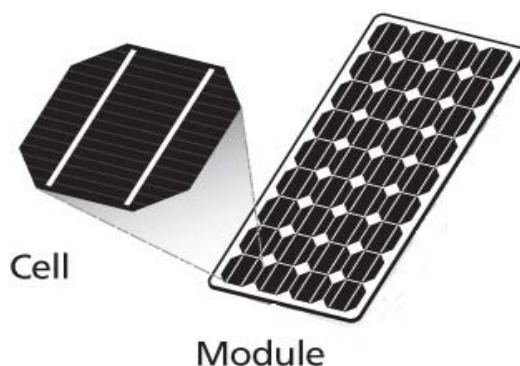


Figure 1: PV cell and Module

c) Photodetector or Photosensor

Photodetector or Photosensor is a device that can detect the presence of photons and converts optical signal to electrical signals [9]. Photodiodes operate in Photovoltaic or Photoconductive mode. In the photoconductive mode the photodiode operates in reverse bias and thus creates electric fields and increases the width of space charged region. When light falls, depending on the energy of the photon $h\nu$,

electrons –holes pair are generated in the space charged region and the electric field (due to reverse bias) will sweep away the e-h pairs and produces current in the external circuit[10]. In developing the solar automatic vehicle, photosensors / photodetectors are used. These photodetectors can detect black or white color, by which the vehicle can sense where it is and moves accordingly on the road.

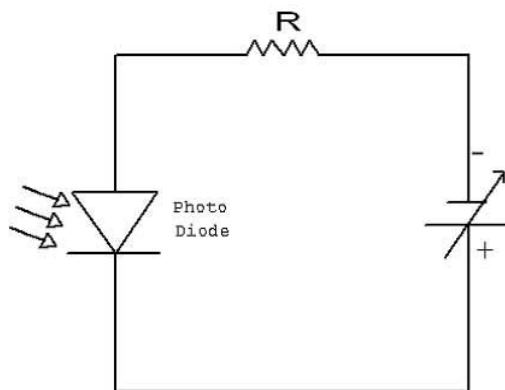


Figure 2 : Photodiode [11]

d) Motor Driver

Motor driver is a device which can drive motor or motors. Motor driver is used because a motor needs high current and a motor driver, amplifies low current to necessary high current, which drives the motor [12]. In designing the solar automated vehicle L293D motor driver IC is used. L293D has two inbuilt H-bridge driver circuits to drive two motors simultaneously. It is called H-bridge because four switches are arranged such that it resembles like 'H'. Shown in figure 3.

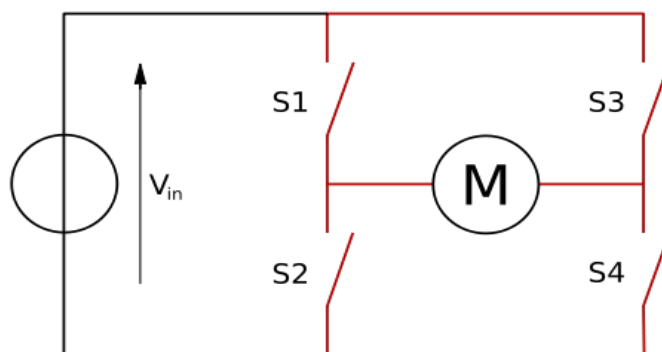


Figure 3 : H-bridge driver circuits [13]

The motor rotates in forward in clockwise direction, when switch **S1** and **S4** are **closed** and switch **S3** and **S2** are kept **open** and the motor rotates in reverse or in anti-clockwise direction, when **S3** and **S2** are **closed** then and **S1** and **S4** are kept **open**.

e) Relay

A relay is an electrically controlled electro-mechanical switch. It operates on the principle of electromagnet[14]. By the relay control circuit, when the relay coil is energized, the electromagnetic field of the coil forces the common switch element (moving part of the switch) inside the relay to disconnect its contact with the normally closed (NC) terminal and make connection with the normally open (NO) terminal. Otherwise, when the relay coil is not energized, the common switch element will stay at normally closed (NC) terminal.

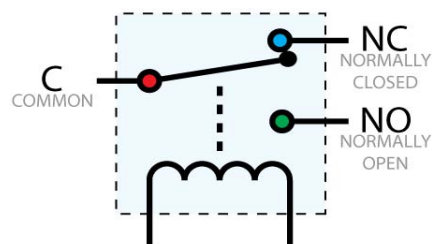


Figure 4 : Relay [15]

III. PRINCIPLE OF SOLAR AUTOMATED VEHICLE

a) Block diagram of photosensor based automated solar vehicle

While the vehicle is on the road the black color is detected by the photosensors and if the vehicle is outside the road or there are any obstructions, white color is detected by the photosensors.

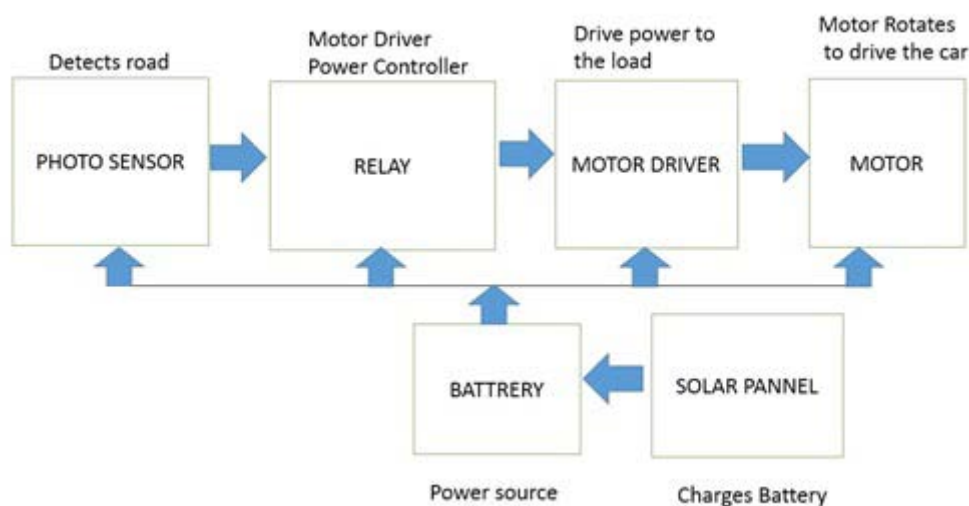


Figure 5 : Block diagram of photosensor based solar automated vehicle

After detection of light, the photosensors convert the light signal to electrical signal. Depending upon the electrical signal, the relay will provide isolation or electrical signal to the motor driver, the motor driver

will provide necessary current to drive the motor and thus the vehicle will move around the road. The battery ensures necessary power to every components and a solar panel charges the battery.

b) *Block diagram of microcontroller based automated solar vehicle*

The only difference in the block diagram of microcontroller based solar automated vehicle is that instead of a relay block (in figure 5) there is a

micro controller block (figure 5). The relay function is done by using microcontroller. After getting electrical signal from the photodiodes, the microcontroller sends control signal to the motor driver to drive the motor and the vehicle moves around the road.

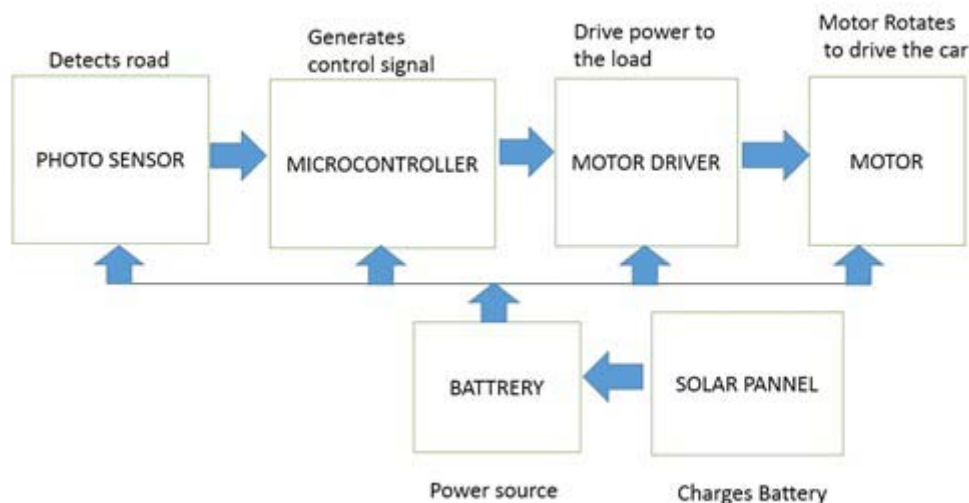


Figure 6 : Block diagram of microcontroller based solar automated vehicle

IV. SCHEMATIC DIAGRAM OF SOLAR AUTOMATED VEHICLE

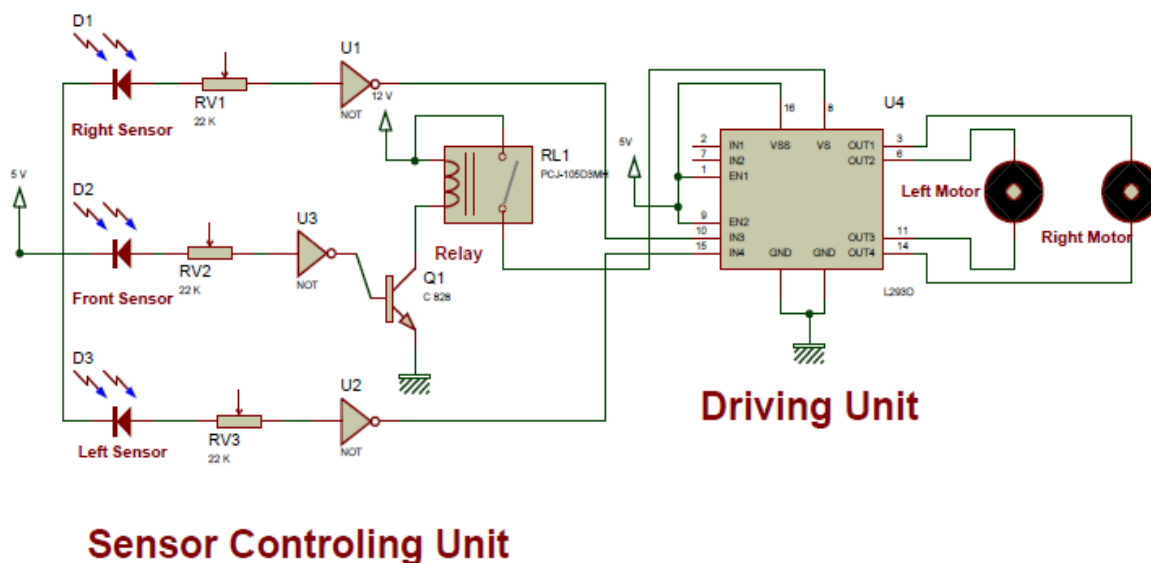


Figure 7 : Schematics of three photosensor based solar automated vehicle

Figure 7 shows the schematic diagram of three photosensor based solar automated vehicle. The schematic was drawn using Proteus Lite software. When there is no obstacle and no right or left turn is needed, there is only straight forward path, then the left and

right photosensor detects black light and convert the black light to 0 volt, which goes through the not gate thus producing 5 volt to the input 3 and 4 (pin 10 and pin 15) of L293D motor driver IC. Thus inputting binary 11 signal to motor driver IC rotates both the motor and

the vehicle moves forward. When the vehicle needs to turn right, the left photosensor will detect white color, thus converting the white color to 1 volt, which goes through the not gate thus producing 0 volt to the input 4 (pin 15) of L293D motor driver IC. At this moment the right photosensor detect black light and convert the black light to 0 volt, which goes through the not gate thus producing 5 volt to the input 3 (pin 10) of L293D motor driver IC. Because inputting binary 01 signal to motor driver input 3 (pin 10) and input 4 (pin 15) will give 12 volt to output pin 11 and 0 volt to output pin 14, So the right motor (figure 7) will stop and the vehicle will turn to the right. If there is a left turn, then right photosensor will detect white color and the left photosensor will detect

black color, producing binary 10 signal to motor driver input 4 (pin 15) and input 3 (pin 10) will give 12 volt to output pin 14 and 0 volt to output pin 11, thus stopping the left motor (figure 7) and the vehicle will turn left. But if there is obstruction, the front sensor will detect white color, convert it to 1 volt, which goes through the not gate thereby producing 0 volt at the base of transistor. Thus the transistor will remain open, the relay coil will never magnetized, then the common switch element (moving part of the switch) remain open, 12 volt power will not go L293D motor driver IC power supply (VS, pin-8), making it powerless, and thereby making both the motor stops, as a result also making the vehicle stop.

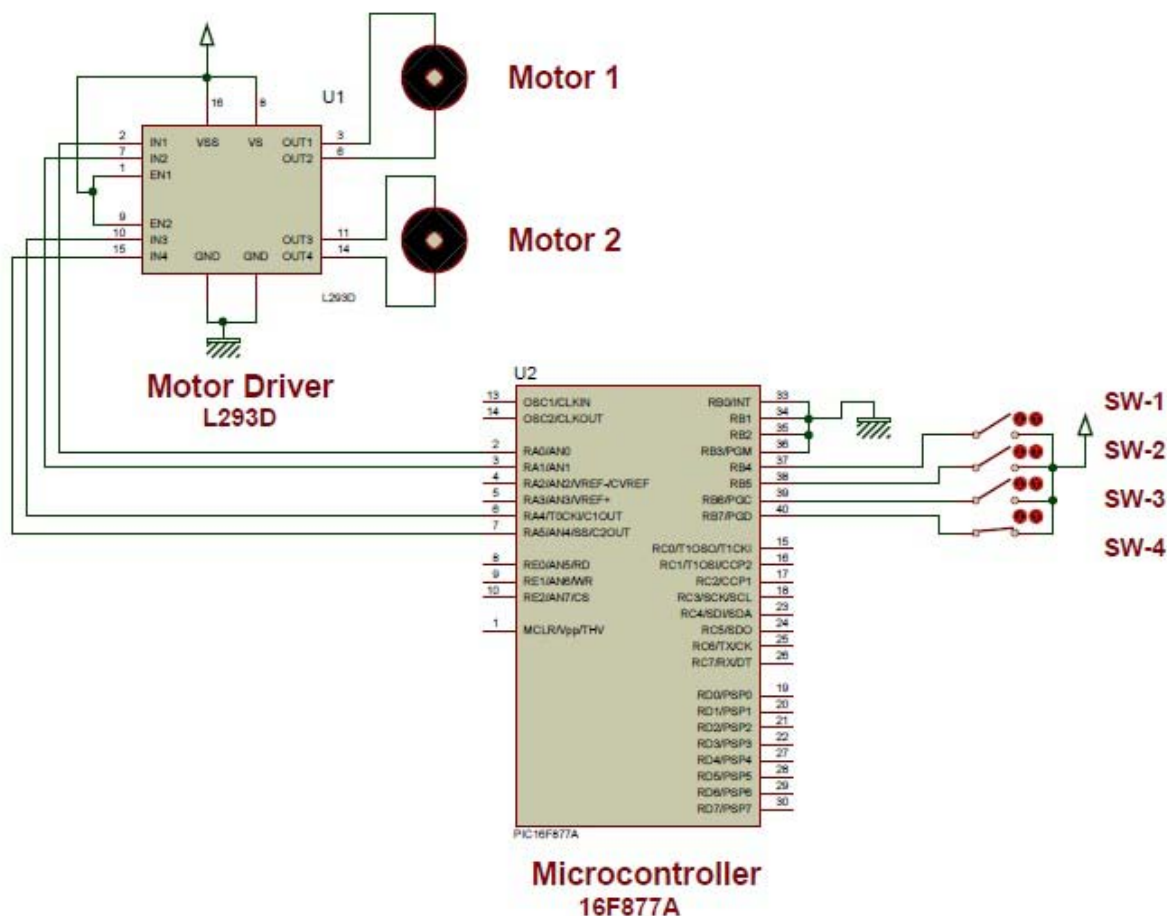


Figure 8 : Schematics of microcontroller based solar automated vehicle

Figure 8 shows the schematic diagram of microcontroller based solar automated vehicle. This schematic was also drawn using Proteus Lite software.

The procedure is almost same as three photosensor based solar automatic vehicle. In the previous schematic the driver circuit got signal directly from the photosensor. Here the photosensor first send signal to the microcontroller. Microcontroller then send signals to the driver IC, and thus the vehicle operates.

MicroC Pro for PIC software was used to program the PIC16F877A microcontroller. For simulation to run photosensors were replaced by switches. The switches does the same function as photosensor in the simulation. When the switch is closed binary 1 is considered and when switch is open binary zero is considered. The automated vehicle function is summarized in the following table

Table1: Condition for vehicle moving on the road

Input signal	Output signal	Function
$RB4=1, RB5=1, RB6=1 \& RB7=1$	$RA0=1, RA1=0, RA4=1 \& RA5=0$	Car will go forward
$RB4=0, RB5=0, RB6=0 \& RB7=0$	$RA0=0, RA1=0, RA4=0 \& RA5=0$	Car will stop
$RB4=1, RB5=1, RB6=0 \& RB7=0$	$RA0=1, RA1=0, RA4=0 \& RA5=0$	Car will turn left
$RB4=0, RB5=0, RB6=1 \& RB7=1$	$RA0=0, RA1=0, RA4=1 \& RA5=0$	Car will turn right
Other condition	$RA0=1, RA1=0, RA4=1 \& RA5=0$	Car will go forward

V. BATTERY CHARGING SECTION

A 12 volt Battery is used as power source of the solar automated vehicle. To charge the 12 Volt battery a 16 Volt, 12 Watt solar panel is directly connected (figure 9). The main purpose of using solar panel was to see

whether the vehicle will be able to carry the weight upon driving. It is seen that, the vehicle can easily carry the weight of solar panel. Solar charge controller is not designed for this solar automatic vehicle, but it is proposed that a solar charge controller should be designed for better battery charge control.

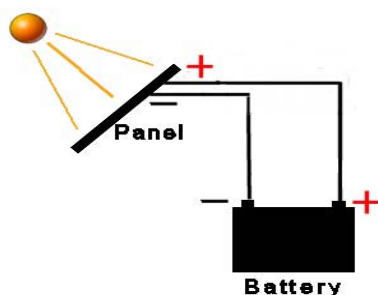


Figure 9 : Solar panel directly connected to battery

Beside the solar panel directly charging the battery, there is an alternative option to charge the battery of the vehicle directly from the 220 Volt AC line. The schematic of 220 A.C to 16 volt D.C charge controller is shown in the Figure 10. Here, mainly the

four diodes are used as full wave bridge rectifier. The full wave bridge rectifier converts the A.C voltage to D.C voltage. With this circuit the vehicle battery charging operation can operate like a mobile charger.

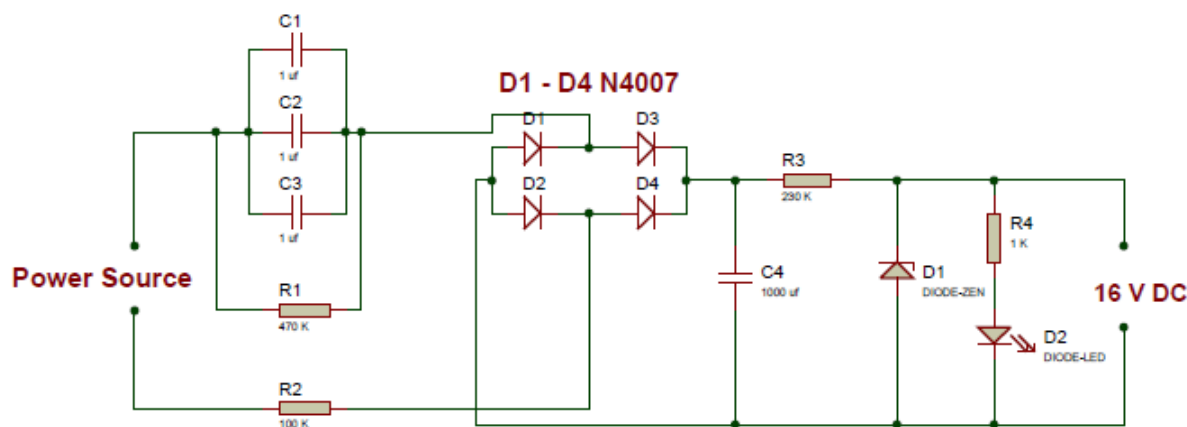


Figure 10 : 220 volt A.C to 16 volt D.C conversion circuit

VI. IMPLEMENTING SOLAR AUTOMATED VEHICLE

According to the schematics, at first all the equipment was soldered into veroboard and the three photosensor based solar automatic vehicle was developed. Figure 11 shows the internal circuitry of the

solar automated vehicle. After assembling the prototype was tested first, then a road was constructed using black and white paper and seen that the solar automated vehicle moves around the road quite easily (Figure 12). An obstacle, was placed on the road while the vehicle was moving, and instantly the automated vehicle detect the obstacle and stop.

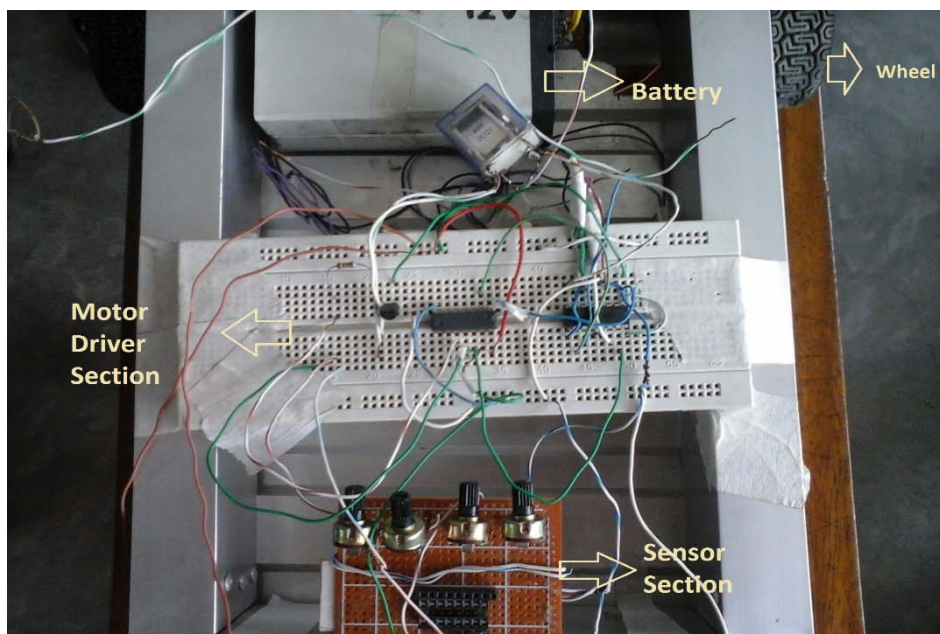


Figure 11: Internal circuit of solar automatic vehicle

A video of the solar automated vehicle is uploaded to you tube website [16]. After developing the three photosensor based solar automatic vehicle a microcontroller based solar automatic vehicle was developed and tested on the road. The microcontroller

based vehicle also work accurately as the three photosensor based solar automated vehicle. Figure 13 shows the microcontroller section and the microcontroller based solar automated vehicle.



Figure 12 : Prototype vehicle testing (on the left) & three photosensor based automated solar vehicle on the road

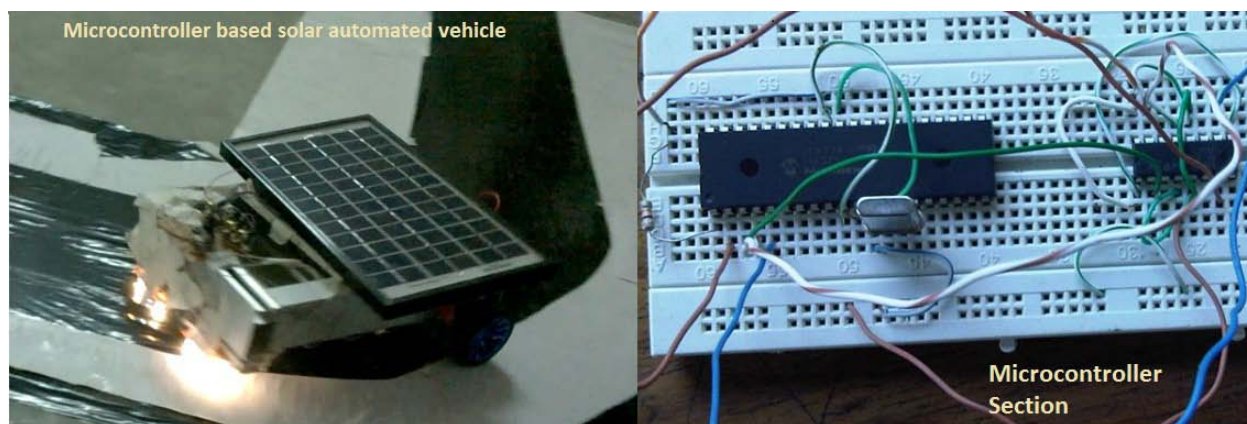


Figure 13 : Developed microcontroller based solar automated vehicle (on the left) & internal microcontroller section circuitry image (on the right)

VII. DISCUSSION & CONCLUSION

It is seen that both design of solar automatic vehicle operates smoothly in the road. Furthermore, it is seen that the three photosensor based solar automated vehicle operates better than microcontroller based solar automated vehicle on the road. But the microcontroller

will be able to provide more options because a real vehicle needs more options. It is seen that cost variation (From table 2) between microcontroller based and three photosensor based solar automated vehicle is less, so for further research work, a vehicle having more options it is suggested that microcontroller to be used.

Table 2 : Cost comparison between developing two system

Three photosensor based solar automated vehicle		Microcontroller based solar automated vehicle	
Product Name	Cost(tk)	Product Name	Cost(tk)
a) Motor Driver IC	90 tk	a) Microcontroller	250 tk
b) Motor (2 pieces)	600 tk	b) Motor Driver IC	90 tk
c) Car Frame	200tk	c) Motor (2 pieces)	600 tk
d) Resistors(5 pieces)	100 tk	d) Car Frame	200tk
e) Photosensors	50 tk	e) Resistors(5 pieces)	100 tk
f)Veroboard	30 tk	f) Photosensors	100 tk
g) Battery	600 tk	g)Veroboard	30 tk
h) Solar panel	1200 tk	h) Battery	600 tk
i)Car Wheel	150 tk	i) Solar panel	1200 tk
j)Others Apparatus	200 tk	j)Car Wheel	150 tk
		k)Others Apparatus	200 tk
Total cost	3220tk/ 40.25\$	Total cost	3520tk/ 44.00\$

Though the car moves successfully on the road there are some limitations. The vehicle cannot stop until the end of the road or switched off. Also the vehicle cannot park it on the side of the road. This problem can be solved, in the microcontroller based solar automatic vehicle. There should be a switch which can turn of the photosensors, and the vehicle will have to operate manually. Left, right turn and all other options can be done using (like in figure 8) switching function. Another limitation is there is no solar charge controller, it would be appropriate, if solar charge controller is incorporated with the vehicle to function more efficiently.

Despite the limitations, there are lot of advantages, like use renewable energy, safe driving, not producing any smokeand noise, very light weight, low cost etc. Still many research work is needed to bring the solar automated vehicle on the road for commercial use. Hopefully, the day is not too far away that everybody will see solar automated vehicle on the road.

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