Solar Operated Photovoltaic Line Follower Robot

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Abstract - In today's world of industrialization, no single branch of Engineering and Technology can be considered independent. In order to increase productivity and profitability, industrial products are designed with the technology involving Mechanical and Electronics principles i.e. Mechatronics. Robotics is one of the developing areas in mechatronics & has a vital importance in various fields such as agricultural, aviation, automobile, medical, non-conventional energy systems, space technology etc. In context of energy crisis, the concentrated efforts are very much necessary to increase the energy transformation efficiency along with energy conservation. The successful attempt has been made in the present work to design, manufacture and test the solar operated Line Follower Robot. The Robot follows black line path & also it can be automatically moved in all four directions free from the black lined path using Infrared sensors (IR). The robot is controlled by burning embedded C programming in ATMEGA 8 Microcontroller and is operated using two DC motors to drive two wheels. Photovoltaic effect is used for the rotation of the motor that enable the movement of the robot. As solar energy is clean, green, free and widely available, can be one of the best alternatives for the current robot operations. In the current paper the same concept is proposed and illuminated in detail.

Keywords— Solar panel, microcontroller, photovoltaic cell, robot, IR sensors.

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1 INTRODUCTION

A robot is a self controlled device that is built using electrical & mechatronics discipline as well as components. It is designed to carry out a specific set of instructions that it is programmed for. They were initially used in industries to handle radioactive material because they were harmful to people & as technology advanced, their were very slow but more complex machines, generally limited to a very scant number, which performed more grandiose functions such as those invented by Hero of Alexandria & HONDA ASIMO. (Humanoid robot) [1].

Fig.1. Humanoid robot.

2 LINE FOLLOWER ROBOT

The line follower is a self operating robot that detects & follows a line that is drawn on the floor. The path consists of a black line on a white surface. The control system used must sense a line & maneuver the robot to stay on course, while constantly correcting the wrong moves using feedback mechanism, thus forming a simple yet effective closed system. The robot is designed to follow very tight curves effectively along its path. [2]
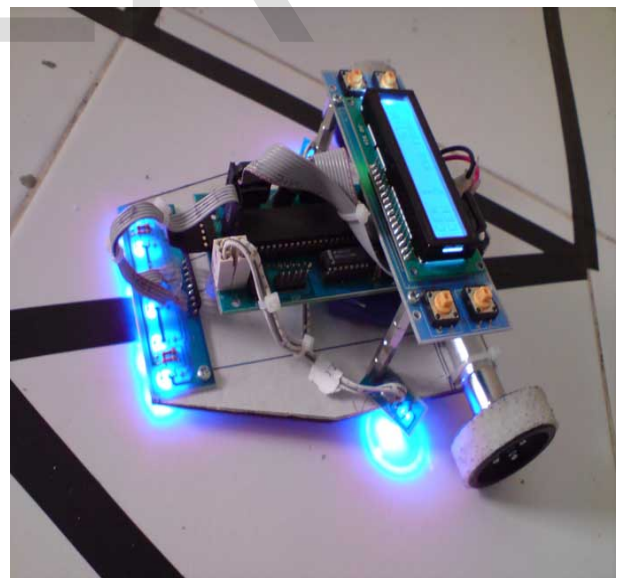

Fig. 2. Line follower robot with electrical energy.

3 SOLAR ENERGY AS AN ALTERNATIVE TO ELECTRICAL ENERGY

Solar energy is the most non-conventional energy source gaining interest throughout the world which has no harmful environmental impact. A space energy source now being considered by many & used to power the robotic mechanism in the form of photovoltaic cell (PV), which is the direct conversion of sunlight to electricity. The renewable energy is a vital part of all available energy, which is capable to fulfill our entire energy requirement [1].Among all available forms of energy the solar energy can be used to run a electronical or robotical mechanism by using PV cells.
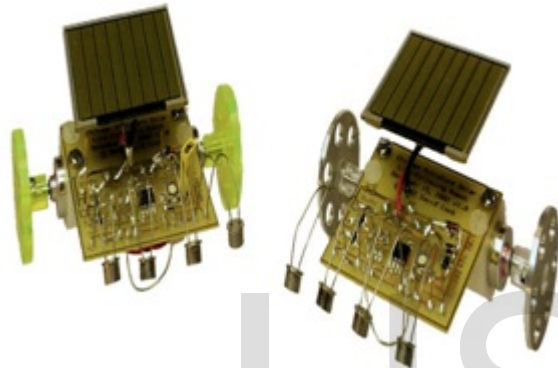
Fig. 3. Line follower robot with solar energy.

4 BASIC DESIGN AND REQUIREMENT

The robot is built with ATmega8L, L293D, IR sensors, LM324, platform consisting of a toy car chassis. The robot is designed using two motors for controlling wheels. It has infrared sensors on the bottom for detecting black tracking tape. It captures the line position with the help of these optical sensors called opto-couplers mounted at front end of the robot. When the sensors detect black surface, output of comparator, LM324 is low logic and for white surface the output is high. It reports to the microcontroller for accurate control and steering of motors. Microcontroller ATmega8L and Motor driver L293D are used to drive the motors. [2]

4.1 BASIC OPERATION

The basic operations of the line follower are as follows:

1. Capture line position with optical sensors mounted at front end of the robot. For this a combination of IR LED's and Photo Transistor called an opt coupler is used. The line sensing process requires high resolution and high robustness.

2. Steer robot to track the line with any steering mechanism. To achieve this we use two motors governing wheels motion. [2]

4.2 BLOCK DIAGRAM

As each sensor has transmiter & receiver, transmited IR rays reflect from white surface & its received by receiver & using comparator, received voltage of IR rays is compared with v-ref.

For white color surface v > v-ref i.e. 5v= 1 in binary, senser will ON. If it is black colour surface, receiver will not get any signal as black colour absorbs all incident rays on it. So for black surface v < v-ref i.e. 0V= 0 in binary, sensor will OFF. Using processer it processes the input signal & gives output to the motor.
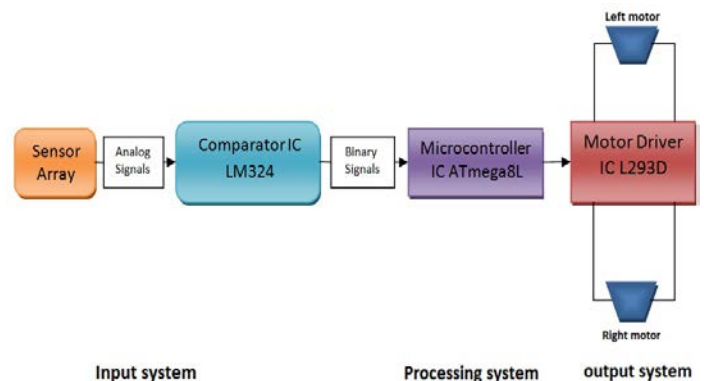
Fig. 4. Block diagram of line follower robot.

4.3 INPUT SYSTEM

1. **IR Sensors:** Two sensors are used in line follower robot. Every sensor has transmitter & receiver. They transmit & receive the IR-rays.
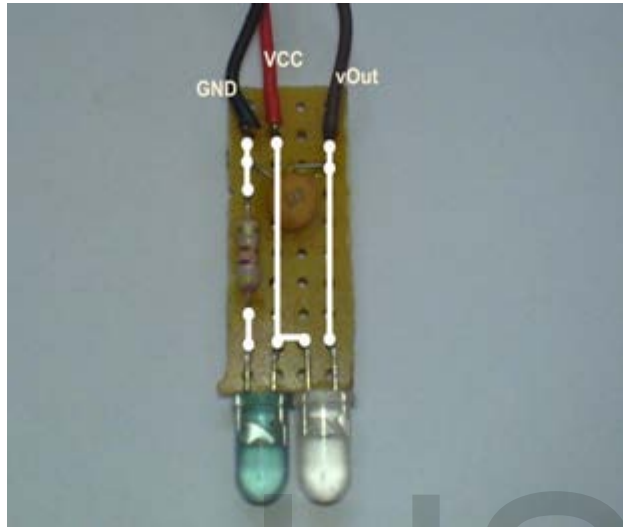

Fig. 5. IR sensors.

If we have white surface it reflects the light and it will be sensed by the receiver, similarly if we have black surface it absorbs the light and receiver will not be able to sense light.
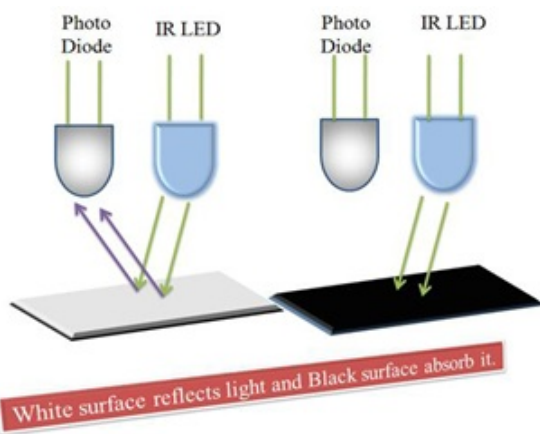

Fig. 6. Property of light.

2. **Comparator:** Comparator is a device which compares two input voltages and gives output high/low.

3. **Use of Comparator:** As above we see that two inputs are required for comparator. One input is from Photo-receiver (like photo-diode), other is generated by us using potentiometer. The second voltage is also called as reference voltage for that sensor. [2]
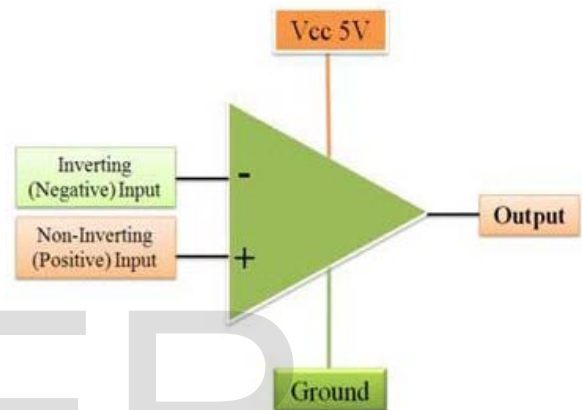

Fig. 7. Circuit diagram of comparator.

Properties of comparator:

If $V+ > V-$

Then $Vo = Vcc$

(Digital **High 1** output)

If $V+ < V-$

Then $Vo = 0$

(Digital **Low 0** output)

Finally, It is clear that in line follower robot if sensor come on white color then emitter emits IR ray, as white color reflect all rays incident on it so receiver receive all the emitted rays, using comparator it compares the voltage of received rays with reference voltage i.e. 5v & sensor will ON. If it comes on black color, as black color absorbs all

emitted rays, receiver will not receive any signal & sensor will go off. Therefore working of sensors i.e. ON & OFF of sensors is based on the principle of comparator.

4.4 PROCESSING SYSYTEM

Processing system acts as the Brain of robot, which generates desired output for corresponding inputs & that's where we use microcontrollers. In present days, there are several companies that manufacture microcontrollers, for example ATMEL, Microchip, Intel, Motorola etc. We will be using ATmega8L microcontroller in our robot, which is an ATMEL product. It is also called AVR. [2]
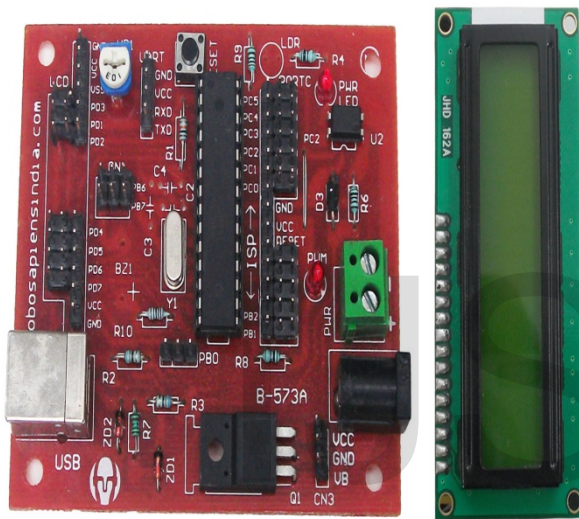
Fig. 8. ATmega8 microcontroller.

Using embedded c-programming language, it is programmed for line follower robot & burned in processor.

ATMEGA 8 MICROCONTROLER consists of:

i.   8-bit registers

ii.   16 mHz processer

iii.   28 pin IC

iv.   0-0V,1-5V

v.   For in between voltage, for egs: 3V ,counters & timers are used for change in supply of current.

vi.   In ATmega8 we have three I/O (input/output) ports viz. Port B, Port C, Port D.

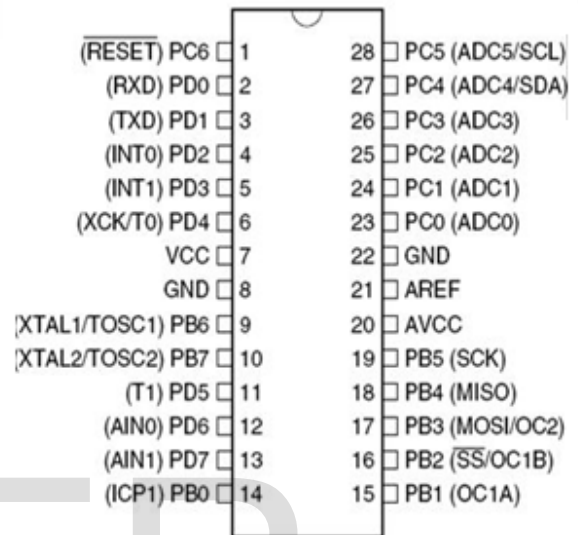vii.   One can configure any pin of all these ports as input or output pin by software.

Fig. 9. Pin diagram of ATmega8 microcontroller.

4.5 MOTOR OUTPUT SYSTEM

Two D.C. motors are attached to individual gears of wheels for the movement of robot.

1. **DC Motors:** DC motors are most easy to control. One dc motor requires only two signals for its operation. If we want to change its direction just reverse the polarity of power supply across it. We can vary speed by varying the voltage across motor. By using two motors we can move our robot in any direction. This steering mechanism of robot is called as differential drive.

2. **IC L293D**: This is a motor driver IC used in the line follower robot, , it is mostly used in robots due to its unique ability to drive two motor simultaneously.

Fig. 10. DC motor.

3. **Output Connections:**

i. OUTPUT 1 (Pin No 3) --- Negative Terminal of Right Motor

ii. OUTPUT 2 (Pin No 6) --- Positive Terminal of Right Motor

iii. OUTPUT 3 (Pin No 10) --- Positive Terminal of Left Motor

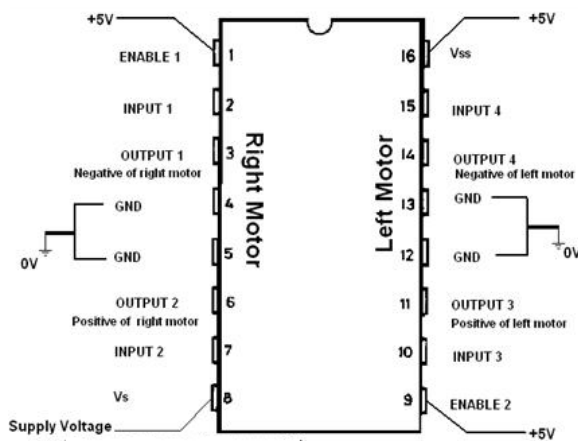iv. OUTPUT 4 (Pin No 14) --- Negative Terminal of Left Motor [2]

Fig. 11. Pin details of L293D.

5. SOLAR ENERGY

Photovoltaic is the field of technology and research related to the devices which directly convert sunlight into electricity & solar cell is the elementary building block of the photovoltaic technology. Solar cells are made of semiconductor materials, such as silicon. One of the properties of semiconductors that make them most useful is that their conductivity may easily be modified by introducing impurities into their crystal lattice. [3]

5.1 SOLAR CELLS

Photovoltaic cells commonly known as solar cells are the devices, which convert the solar energy directly into electricity (electric energy) by using photovoltaic effect. The photovoltaic effect can be best observed in semi-conductors e.g. Germanium and Silicon. These are the elements having resistivity (specific resistance) of the order of 104 to 105 ohmmeter that lies between 10-8 ohmmeter for good conductors and 10-16 ohmmeter for bad conductors (insulators). The ohmic resistance of semiconductors decreases when heated. When a semiconductor is heated, more electrons are available for conduction giving large current, i.e. decrease in resistance. [4]
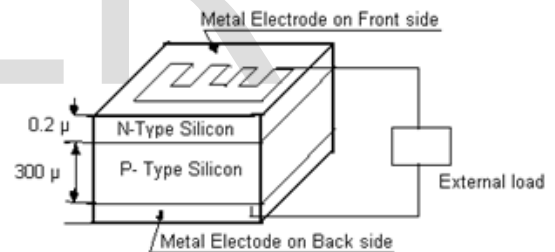

Fig. 12. Solar cell.

5.2 PHOTOVOLTAIC EFFECT:

Consider a p-n junction diode as shown in figure below (figure 13). When solar radiations fall on the junction of the diode, then if the incident photon has sufficient energy to knockout the electron from covalent bond, the electron-hole pair (EHP) is created.
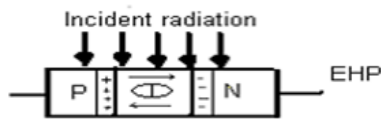
Fig. 13. Photovoltaic effect

If EHP is created in the p-region then current cannot be set up across the junction due to bound charges at the boundary at the depletion region i.e. at window. Similar situations exist if EHP is created in the n-region due to bound positive charge. However, if EHP is created in the depletion region then the holes are attracted towards p-region and electrons are attracted towards n-region. Thus, an electric current is set up through diode. As a result, a voltage drop is developed across semiconductor due to incidence solar radiations. In this way, the p-n diode is used as a device to collect the solar energy and convert it into electrical energy.

5.3 LINE FOLLOWER ROBOT WITH SOLAR APPLICATION

As solar panel are mounted on robot, the sunrays incident on the solar panel i.e. solar energy is absorbed and is converted into electrical energy by using photovoltaic effect. This energy is stored in the battery, which is used to operate the line follower robot. The above discussed whole mechanism and system is run on the following principle and when assembled together turns out to be a eco-friendly machine. As solar energy is clean, green, free and widely available, it can be one of the best alternatives for the current robot operations.

6 SCOPE OF LINE FOLLOWER ROBOT

Medical robots are moving from the benches of laboratories to the bedside of patients rapidly. With advancements in technology, these are being used for minor services to diagnostic as well as therapeutic. The navigation path planning can be concluded by an information decision making system. A Line Follower Robot for Transport Applications in Hospital Domain is one of the good choices [5]. It is decided from the

distribution of people in the hospital. There are many ways in which these robots can be tasked for human allowance and also improving the hospital service.

7 CONCLUSION

The most abundant and non hazardous source of energy on our planet is being used today in many fields & its not far when it will become prime source of energy. Many applications are under development consuming this source and will be technologically and practically implemented in day to day life in near future.

8 REFERENCES

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