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Study and Implemenation of Solar Botics

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Abstract— The battery life of robots is increasing by harvesting energy from the environment with photovoltaic solar panels. Solar harvesting has proven to be useful in marine and extra-terrestrial robotics applications which take place in open space. This is a far more cost effective solution than purchasing additional solar panels. It has been estimated that the yield from solar panels can be increased by 30 to 60 percent by utilizing a tracking system instead of a stationary array. The system implemented in paper develops an automatic tracking system which will keep the solar panels aligned with the sun in order to maximize efficiency, then after one can add a battery which can be charged through solar panels. The battery is finally connected to a robot which performs the desired activity.

Keywords— Sensor, CPU, Stepper Motor, Solar Panel

I. INTRODUCTION

Mobile robots have the potential to perform many critical outdoor tasks but their potential for long-term deployment is limited due to energy concerns. A possible method to increase the battery life of robots is by harvesting energy from the environment, e.g. with photovoltaic Solar panels. Solar harvesting has proven to be useful in marine and extra-terrestrial robotics applications which take place in open space. Renewable energy solutions are becoming increasingly popular. Photovoltaic systems are one of the examples. Maximizing power output from a solar system is desirable to increase efficiency. In order to maximize power output from the solar panels, one needs to keep the panels aligned with the sun. As such, a means of tracking the sun is required. This is a far more cost effective solution than purchasing additional solar panels. It has been estimated that the yield from solar panels can be increased by 30 to 60 percent by utilizing a tracking system instead of a stationary array. This system develops an automatic tracking system which will keep the solar panels aligned with the sun in order to maximize efficiency, then after one can add a battery which can be charged through solar panels. The battery is finally connected to a robot which performs the desired activity. This system begins with presenting background theory in light sensors and stepper motors. Further it continues with specific design methodologies pertaining to photocells, stepper motor and drivers, microcontroller selection, voltage regulation and physical construction. The most challenging part of the entire system is designing and interfacing various stages together. The approach is to convert solar energy into electrical energy and in turn used to drive the robot. The block diagram of complete system is shown in Figure 1 it contains solar panel, light sensor, control unit, stepper motor, battery and robot.

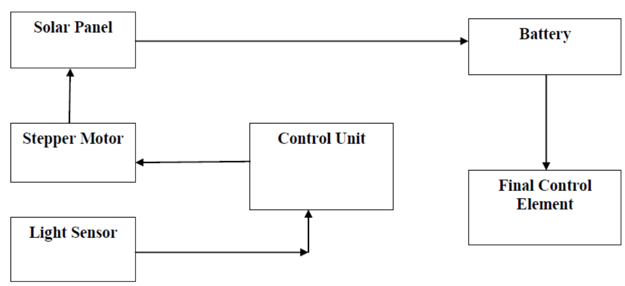

Figure.1:- Block Diagram

The Description of each Block is:

***Light Sensor**:* Light sensors are among the most common sensor type. The simplest optical sensor is a photo-resistor which may be a Cadmium sulfide (CdS) type or a Gallium arsenide (GaAs). The sun tracker uses a Cadmium sulfide (CdS) photocell for light sensing. This is the least expensive and least complex type of light sensor. The CdS photocell is a passive component whose resistance is inversely proportional to the amount of light intensity directed towards it.

Control Unit: Since the project's focus is on embedded software control, the microcontroller is the heart of the system. The microcontroller used for this project had to be able to convert the analog photocell voltage into digital values and also provide four output channels to control motor rotation.

***Stepper Motor:* -** It divides a full rotation into equal no of rotations. It has step angle of 1.8 degree.
***Solar Panel:* -** Solar Panel (also Photovoltaic module) is a packaged connected assembly of photovoltaic cells. The Solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential.
***Solar Cell Battery:* -** The batteries are charged by the Solar panels. In this prototype model 12 Volts battery is used.
***Final Control Element:* -** It consists of two dc motors which are interfaced with motor driver to move the robot into desired direction using RF module.

The block diagram of complete system implemented in paper develops an automatic tracking system which will keep the solar panels aligned with the sun in order to maximize efficiency, then after one can add a battery which can be charged through solar panels. The battery is finally connected to a robot which performs the desired activity**.** Rest of the paper is organized as follows Section I contains the introduction of solarbotics, Section II contain the system hardware description, Section III describes results and discussion, Section IV concludes.

II. SYSTEM HARDWARE

The system hardware consists of following components: solar panels, light sensor, RF module, control unit, stepper motor, solar cell battery and control element.

SOLAR PANELS: A solar cell (also known as photovoltaic cell) is an electrical device that converts the energy of light directly into electricity by photovoltaic effect. It is a form of photoelectric cell which when exposed to sun light, can generate and support an electric current without being attached to any external voltage source. Its current and voltage vary with the variation in the intensity of light. Solar Panel uses photons from the sun to generate electricity through the photovoltaic effect. The majority of modules uses wafer based crystalline silicon cells or thin-film cells based on silicon. The structural (load carrying) member of a module can either be the top layer or back layer. An encapsulated PC film lamination is used to protect solar panel from mechanical damage and moisture. A typical Solar panel is shown in Figure 2.

The solar panel works in three simple steps are
1. Photons in sunlight hit the solar panel and are absorbed by semi conducting materials, such as silicon.
2. Electrons (negatively charged) are knocked loose from their atoms, causing an electric potential difference. Current starts flowing through the material to cancel the potential and this electricity is captured. Due to the special composition of solar cells, the electrons are only allowed to move in a single direction.
3. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

Figure.2: - Solar Panel

LIGHT SENSORS: There is a wide selection of photosensitive devices that are available to the electronic designer. Whilst photo-diodes full fill many requirements, photo transistors are also available, and are more suitable in some applications. Providing high levels of gain and standard devices are low cost, these phototransistors can be used in many applications. The light sensor used is shown in the Figure.3.

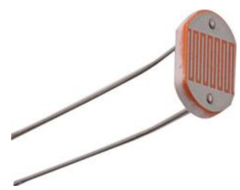

Figure.3: - Light Dependent Resistor.

Although ordinary transistors exhibit the photosensitive effects if they are exposed to light, the structure of the phototransistor is specifically optimized for photo applications. The photo transistor has much larger base and collector areas than would be used for a normal transistor. These devices were generally made using diffusion or ion implantation. The basic Photo Transistor structure is shown in the Figure.4.

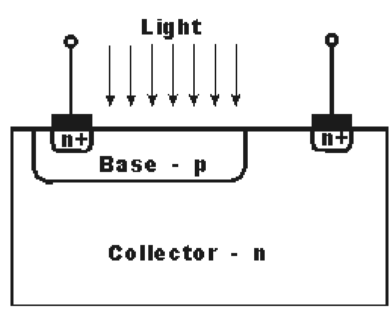

Figure.4:- Basic Photo Transistor Structure.

Phototransistor operation: Photo transistors are operated in their active region, although the base connection is left open circuit or disconnected because it is not required. The base of the photo transistor would only be used to bias the transistor so that additional collector current could flow and this would mask any current flowing as a result of the photo-action. For operation the bias conditions are quite simple. The collector of an n-p-n transistor is made positive with respect to the emitter or negative for a p-n-p transistor. The light enters the base region of the phototransistor where it causes electron-hole pair to be generated. This mainly occurs in the reverse biased base-collector junction. The hole-electron pairs move under the influence of the electric field and provide the base current, causing electrons to be injected into the emitter.

Phototransistor characteristics: As already mentioned the photo transistor has a high level of gain resulting from the transistor action. For homo-structures, i.e. ones using the same material throughout the device, this may be of the order of about 50 up to a few hundred. However for the hetero-structure devices, the levels of gain may rise to ten thousand. Despite their high level of gain the hetero-structure devices are not widely used because they are considerably more costly to manufacture. A further advantage of all phototransistors when compared to the avalanche photodiode, another device that offers gain, is that the phototransistor has a much lower level of noise. One of the main disadvantages of the phototransistor is the fact that it does not have a particularly good high frequency response. This arises from the large capacitance associated with the base-collector junction. This junction is designed to be relatively large to enable it to pick up sufficient quantities of light. For a typical homo-structure device the bandwidth may be limited to about 250 kHz. Hetero-junction devices have a much higher limit and some can be operated at frequencies as high as 1 GHz. They are very similar to the characteristics of a conventional bipolar transistor, but with the different levels of base current replaced by the different levels of light intensity. There is a small amount of current that flows in the photo transistor even when no light is present. This is called the dark current, and represents the small number of carriers that are injected into the emitter. Like the photo-generated carriers this is also subject to the amplification by the transistor action. Figure.5 shows the Voltage divider circuit for Light Dependent Resistor.

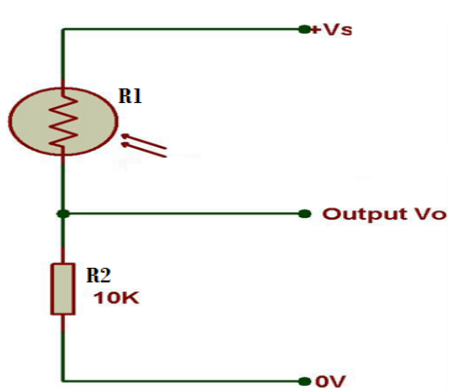

Figure.5:- Voltage divider circuit for LDR.

$$V_{out} = (V_{in} * R2)/(R1+R2)$$

RF MODULE:

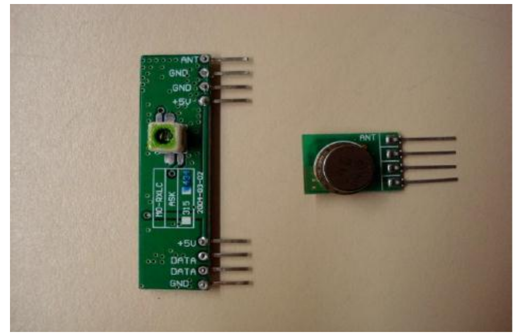

Figure.6: - RF Module

The RF module, as the name suggests, operates at Radio Frequency. The corresponding frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK). A RF module (transmitter and receiver) is shown in Figure.6. Transmission through RF is better than IR (infrared) because of many reasons. Firstly, signals through RF can travel through larger distances making it suitable for long range applications. Also, while IR mostly operates in line-of-sight mode, RF signals can travel even when there is an obstruction between transmitter & receiver. Next, RF transmission is more strong and reliable than IR transmission. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources. This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter. The RF module is often used along with a pair of encoder/decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder. HT12E-HT12D, HT640-HT648, etc. are some commonly used encoder/decoder pair ICs.

TRANSMITER MODULE:-

HT12E ENCODER: HT12E is an encoder integrated circuit of 2^12 series of encoders. They are paired with 2^12 series of decoders for use in remote control system applications. It is mainly used in interfacing RF and infrared circuits. The chosen pair of encoder/decoder should have same number of addresses and data format. Simply put, HT12E converts the parallel inputs into serial output. It encodes the 12 bit parallel data into serial for transmission through an RF transmitter. These 12 bits are divided into 8 address bits and 4 data bits. HT12E has a transmission enable pin which is active low. When a trigger signal is received on TE pin, the programmed addresses/data are transmitted together with the header bits via an RF or an infrared transmission medium. HT12E begins a 4-word transmission cycle upon receipt of a transmission enable. This cycle is repeated as long as TE is kept low. As soon as TE returns to high, the encoder output completes its final cycle and then stops.

RF TRANSMITTER:
The RF Transmitter is ideal for remote control applications where low cost and longer range is required. The transmitter operates from a1.5-12V supply, making it ideal for battery-powered applications. The transmitter employs a SAW-stabilized oscillator, ensuring accurate frequency control for best range performance. A schematic of RF Transmitter is as shown in the Figure.7.

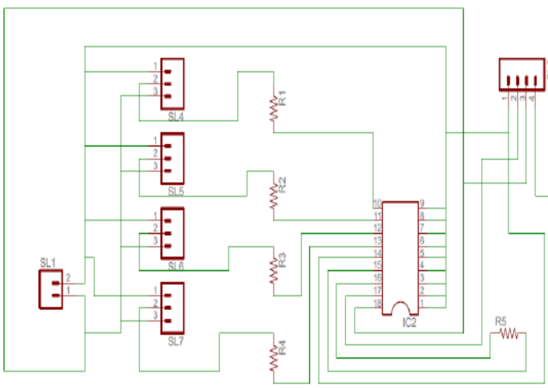

Figure.7:- Schematic of RF Transmitter.

RECIEVER MODULE:-
HT12D DECODER: HT12D is a decoder integrated circuit that belongs to 2^12 series of decoders. This series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system etc. It is mainly provided to interface RF and infrared circuits. They are paired with 212 series of encoders. The chosen pair of encoder/decoder should have same number of addresses and data format. In simple terms, HT12D converts the serial input into parallel outputs. It decodes the serial addresses and data received by, say, an RF receiver, into parallel data and sends them to output data pins. The serial input data is compared with the local addresses three times continuously. The input data code is decoded when no error or unmatched codes are found. A valid transmission in indicated by a high signal at VT pin. HT12D is capable of decoding 12 bits, of which 8 are address bits and 4 are data bits. The data on 4 bit latch type output pins remain unchanged until new is received.

RF RECEIVER: The data is received by the RF receiver from the antenna pin and this data is available on the data pins. Two Data pins are provided in the receiver module. Thus, this data can be used for further applications. The data transmitted into the air is received by the receiver. The received data is taken from the data line of the receiver and is fed to the decoder .The output of decoder is given to Microcontroller and then data is processed according to the Pre-programmed instructions. A schematic of RF Receiver is as shown in the Figure.8.

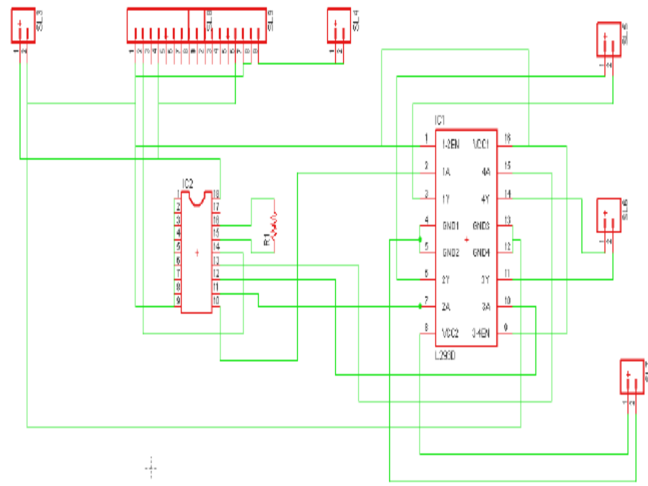

Figure.8:- Schematic of RF Receiver

PIN DESCRIPTION:

Transmitter Module: -

Table No.1:- Pin description of Transmitter Module.

Pin Number	Function	Name
1	Ground (0V)	GND
2	Serial Data Input Pin	DATA
3	Supply Voltage (5V)	VCC
4	Antenna Output Pin	ANT

Receiver Module: -

Table No.2: - Pin description of Receiver Module.

Pin Number	Function	Name
1	Ground (0V)	GND
2	Serial Data Output Pin	DATA
3	Linear Output Pin; Not Connected	NC
4	Supply Voltage (5V)	VCC
5	Supply Voltage (5V)	VCC
6	Ground (0V)	GND
7	Ground (0V)	GND
8	Antenna Input Pin	ANT

MOTOR DRIVER: - It is used to drive motors. According to given instruction from RF Receiver; it drives motor forward, backward, left and right. So basically, L293D is a motor driver IC. The L293D is a dual H-bridge motor driver integrated circuit. Motor drivers act as current amplifiers as in they take a low current control signal and provides a higher-current control signal. This higher current signal is used to drive the motors L293D contains two inbuilt H-bridge driven circuits. The H-bridge arrangement is generally used to reverse the polarity of the motor, but can also be used to 'brake' the motor, where the motor comes to a sudden stop, as the motor's terminal are shorted, or to let the motor 'free run' to stop, as the motor is effectively disconnected from the circuit. The Table No.4.Summarizes the operation, with S1-S4 corresponding to the diagram shown in Figure.9.

Table No.3: - Conditions for DC Motor control

S1	S2	S3	S4	Result
0	0	0	0	No results
1	0	1	0	Motors rotates in one direction
0	1	0	1	Motors rotates in other direction
1	1	0	0	Motor brakes
0	0	1	1	Motor brakes

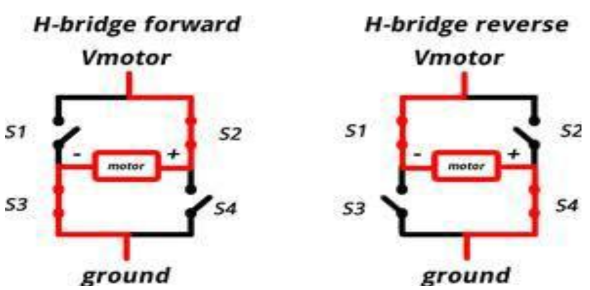

Figure.9: - H-Bridge working principle

CONTROL UNIT: -

The Microcontroller employed here is ATMEL AT89C51. This is used to interface with the entire peripheral device. The output from light sensor is given to the Control Unit which in turn rotates the Stepper motor so as to follow the sun radiation. AT89C51 is an 8-bit microcontroller and belongs to Atmel's 8051's family. It is a low-power, high performance CMOS 8-bit micro-computer with Kbytes of Flash Programmable and Erasable Read Only Memory. The device is manufactured using Atmel's high density non-volatile memory technology and is compatible with the industry standard MCS-51 instruction set and pin-out. The on-chip Flash allows the program memory to be reprogrammed in system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful micro-computer which provides a highly flexible and cost effective solution to many embedded control applications. The AT89C51 provides the following standard feature: 4Kbytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit timers/counters and five vector two-level interrupt architectures, a full-duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The idle mode stops the CPU while allowing the RAM, timer/counters. In 40 pin AT89C51, there are four ports designated as P1, P2, P3 and P0. All these ports are 8-bit bi-directional ports, *i.e.*, they can be used as both input and output ports. Except P0 which needs external pull-ups, rest of the ports have internal pull-ups. When 1s are written to these port pins, they are pulled high by the internal pull-ups and can be used as inputs. These ports are also bit addressable and so their bits can also be accessed individually. Port P0 and P2 are also used to provide low byte and high byte addresses, respectively, when connected to an external memory. Port 3 has multiplexed pins for special functions like serial communication, hardware interrupts, timer inputs and read/write operation from external memory. AT89C51 has an inbuilt UART for serial communication. It can be programmed to operate at different baud rates. Including two timers & hardware interrupts, it has a total of six interrupts. The Port 1 is configured as input port, which gets the input from Light sensors. And Port 0 and Port 2 is configured as output port which rotates the Stepper motor.

STEPPER MOTOR: -

A stepper motor (or step motor) is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application. To achieve full rated torque, the coils in a stepper motor must reach their full rated current during each step. Winding inductance and reverse EMF generated by a moving rotor tend to resist changes in drive current, so that as the motor speeds up, less and less time is spent at full current, thus reducing motor torque. As speeds further increase, the current will not reach the rated value, and eventually the motor will cease to produce torque. The Working of Stepper motor:-

DC brush motors rotate continuously when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first, one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. Now when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and then the process is repeated. Each of those slight rotations is called a "step", with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle.

SOLAR CELL BATTERY:-

A 12v rechargeable battery is used for the operation of robot. The battery is charged from the Solar panel.

FINAL CONTROL ELEMENT: -

It consists of two DC motors which are interfaced with motor driver to move the robot into desired direction using RF module.

DC MOTORS: -

A DC motor is a mechanically commutated electric motor powered from direct current (DC). The stator is stationary in space by definition and therefore its current. The current in the rotor is switched by the commutator to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 90 degrees, which generates the maximum torque. A typical DC Motor is as shown in the Figure.10

Figure.10: - DC Motor

III. Results and Discussion

The RF module was interfaced and tested by making the robot run using remote. Table No-5.1 depicts the output for different inputs. The Solar tracking system was tested by making the Solar panel to track the Sun light.

Table No-4:- Output for different inputs.

Switch 1	Switch 2	Switch 3	Switch 4	MOVEMENT
0	0	0	0	STOP
0	0	0	1	FORWARD
0	0	1	0	REVERSE
0	0	1	1	RIGHT/LEFT

IV. CONCLUSION

By using RF module a remote robot is developed which is useful in places where human find difficult to reach. In order to maximize the power output from the solar panels, one needs to keep the panels aligned with the sun. As such, a means of tracking the sun is required. This is a far more cost effective solution than purchasing additional solar panels. It has been estimated that the yield from solar panels can be increased by 30 to 60 percent by utilizing a tracking system instead of a stationary array. Through the use of a Programmable Control Unit and Light sensors, a Solar tracking system is developed, which will keep the solar panels aligned with the sun in order to maximize efficiency working on this project helped to understand the various aspects of student curriculum in practical scenario. The use of subjects like Microcontrollers and Transducer & Applications was better understood.

The future scope is the robot is useful in places where human find difficult to reach. It can be used in the consumer vehicle sector. It can be used in the green energy productions. It can be used in hospitals to make work easy and it can be used in heavy industries.

Acknowledgment

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References

[1] Vijay Raghunathan, Aman Kansal, Jason Hsu, Jonathan Friedman, Mani Srivastava, "*Design Considerations for Solar Energy Harvesting Wireless Embedded Systems*", In the Proceedings of the 2005 Information processing in sensor network.

[2] Davide Brunelli, Clemens Moser, Lothar Thiele, Luca Benini, "Design of a Solar-Harvesting Circuit for Batteryless Embedded Systems". IEEE Transaction, Vol.56, pp.2519-2528, 2009.

[3] Klar Jager, Olindo Isbella, "*Solar Energy Fundamental, Technology and system*".

[4] Abi Sharma, "Wireless RF modulu".

