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Renewable Energy Powered Gesture Controlled Robot

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Abstract

In order to utilize the renewable energy in the field of robot and conserve the fossil fuels and non renewable energy for our future generation. This reduces the risk of replacement of battery under peak hours. The renewable energy used here is the solar energy. Mathematical modeling and simulation using MATLAB is done and outputs are verified with the hardware observance.

Keywords: *Accelerometer, Gesture Controlled Robot, Solar Panel, Renewable energy energized robot, Rover with solar panel.*

1. Introduction

In India solar potential is high and wind power generations have the limitation of medium wind profile, low plant factor and saturation of optimal wind locations. Solar irradiation is abundant in India by figures (4 -7) kw/m^2 per day in all over the country with 300clear sunny days in a year. The 70% of Indian population are involved in agricultural and living in rural areas. Still 1/3rd of Indian population are not connected to grid electric supply for that reason photo voltaic distributed power generation is most popular. The usage of renewable energy in our generation can save non-renewable energy and fossil fuels in abundance for our future generation. Hence, the robot is powered by means of utilizing renewable energy which can be used in various applications like military, medicine, detection and repairing of power supply in transmission and distribution of electricity, heavy industries where heavy loads are lifted, fitted and manufactured. The robot in this project is a small one in which if the techniques are improvised it can be emphasized in large number of applications.

The task is divided into two parts as shown in Fig.1 and Fig. 2. One is the transmitter session and another is receiver session. The transmitter end consists of an Accelerometer, Arduino Board, Encoder, Transmitter.

The accelerometer records the hand movement in X Y directions and outputs constant analog voltage levels. These potentials are fed to the microcontroller present in the Arduino UNO board. The displacement data is processed as per the program coded in the microcontroller and is sent after encoding to receiver part via transmitter RF module. The transmission is done in ASCII data exchange in RF modules.

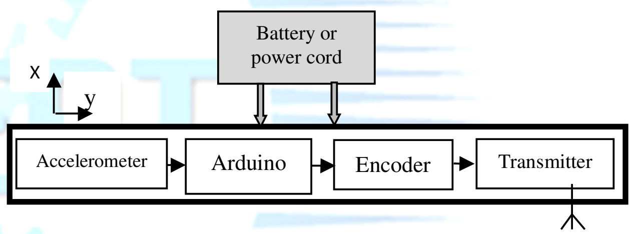

Fig. 1 Transmitter block

The receiver end consists of a Receiver, Decoder, Motor driver, Solar panel, Rechargeable battery, as shown in Fig 2.

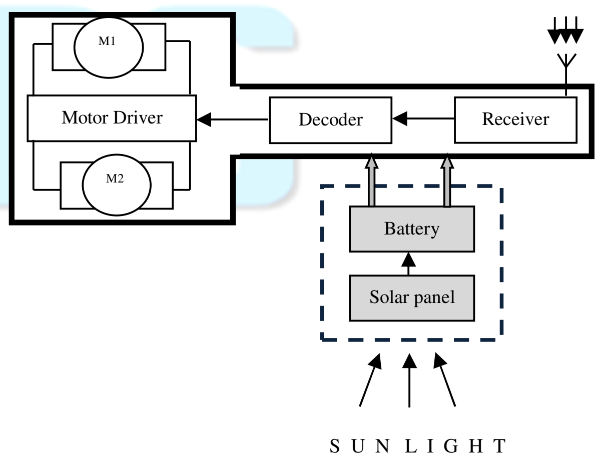

Fig. 2 Receiver block

On the receiver side the robot receives the RF signals and decodes it with the help of a decoder. The decoded signal has appropriate digital HIGH/LOW signals as per the program fed on the transmitter side and flows to the enable pins of DC motor driver. The solar panel is interfaced in battery for the charging of battery.

2. Mathematical modeling of PV array

The newly introduced concept is the utilization of solar energy from the solar panel [4,5]. Mathematical modeling of the solar panel is explained below based on the equivalent circuit of a PV cell, shown in Fig. 3.

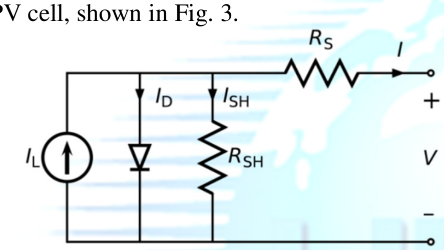

Fig. 3 Equivalent circuit of a PV cell

$$I = I_L - I_D - I_{SH} \tag{1}$$

Five important equations to be considered are
1) Light-Generated Current (I_l)
2) Reverse Saturation Current (I_o)
3) Shape Factor (λ)
4) Series Resistance (R_s)
5) Output power (P_{max})

R_{SH} is considered to be very small in rating and hence its mathematical modeling is neglected [7].

Formulas Used to calculate the unknown important parameters

2.1) Light-Generated Current (I_l):

The light-generated current (I_L) is a function of solar radiation and module temperature, if the series resistance (R_s) and shape factor (λ) are taken as constants. For any operating condition, I_L is related to the light-generated current measured at some reference conditions as [12]

$$I_L = \left(\frac{S_T}{S_{T,r}}\right)[I_{L,r} + \mu I_{SC}(T_C - T_{C,r})] \tag{2}$$

2.2) Reverse Saturation Current (I_o):

The reverse saturation current (I_o) is a function of temperature only[10,12].

$$I_o = \left(\frac{T_C}{T_{C,r}}\right)^3 e^{\xi \lambda \varepsilon_g (T_{C,r} - T_C)/A} \tag{3}$$

2.3) Shape Factor (λ):

Mostly, manufacturers provide information of I-V characteristics curve at three different point using reference conditions, at open circuit voltage (V_{oc}), at short circuit (I_{sc}), and at optimum power point for both the current and voltage [12]

$$\lambda = \frac{q(V_{mp,r} - V_{OC,r} + I_{mp,r} R_S)}{k T_{C,r} \ln\left(1 - \frac{I_{mp,r}}{I_{SC,r}}\right)} \tag{14}$$

2.4) Series Resistance (R_s):

The series resistance (R_s) is an essential parameter when the module is not operating near the reference conditions. This characterizes the internal losses due to current flow inside the each cell and in linkages between cells. It alters the shape of I-V curve near optimum power point and open circuit voltage as shown in Fig 10. However, its effect is small. I-V curve without considering R_s would be somewhat dissimilar than the curves outlined including its value. On the basis of annual simulation, the predicted power output from PV system will be 5% to 8% lower when correct series resistance is not used [12]

$$R_s = 1.8\,\mathrm{Re}\left[\frac{T_C W\left(-1.5\times10^7 e^{0.022\left(47+\left(1.7\times\frac{10^5}{T_C}\right)\right)}\right)}{T_C W\left(-1.5\times10^7 e^{0.022\left(47+\left(1.7\times\frac{10^5}{T_C}\right)\right)}\right)+4400}\right] \tag{18}$$

where Re represents the real part, because the negative expression inside the Lambert W function results in complex number. However, in practical problems only real values are to be considered.

2.5) Output power (P_{max}):

The optimum power output parameters of model were determined by deriving the equations for current (I) and voltage (V) by putting the values of unknown parameters, namely, IL, Io, R and λ, in the respective equations. The power (P) is the product of current (I) and voltage (V) [12]

$$P_{max}=\left\{(I_L + I_o) - \frac{W[\xi R_S e^{\xi[V_{max}+I_L R_S+I_o R_S]}]}{\xi R_S}\right\} \quad (19)$$

Where,

q - Electron charge 1.602×10^{-19}C
k - Boltzmann constant 1.381×10^{-23}J/K
$T_{c,r}$ - Cell temperature at actual conditioin,K
$V_{mp,r}$ - Maximum peak value of PV module reference,V
$I_{mp,r}$ - Maximum current value of PV module reference,A
$I_{sc,r}$ - Short circuit current of PV module reference,A
R_s - Series Resistance, Ω
$V_{oc,r}$ - Open circuit voltage of PV module reference,V
$S_{T,r}$ - Absorbed solar radiation reference,W/m^2
S_T - Absorbed solar radiation ,W/m^2
$I_{L,r}$ - Light- generated current reference,A
μ I_{SC} –Temperature coefficient of Short circuit current of PV module,A
T_C – Cell temperature at actual conditions,K
A - Ideality factor 1 for ideal diodes,between 1 and 2 for real diode
ξ - Parameter $q/KT_c\lambda$
ε_g - Material band gap energy,eV,1.12eV for silicon
W - Lambert W function
I_L - Light- generated current ,A
Io - Diode reverse saturation current,A

3. Experimental Details

Following are the major components used in gesture controlled robot

1) Accelerometer **(adxl335)**
2) Arduino UNO **(containing microcontroller atmega328)**
3) Encoder **(HT12E)**
4) 433MHz 4 channel RF pair
5) Rechargeable battery **(12V,1.3A, Pb acid non spillable)**
6) Motor Driver **(L293D)**
7) DC motor **(12V, 60 RPM)**
8) Solar Panel (Specifications are in Table I

Table 1
Solar Panel Specifications

S.No	SPECIFICATION	RATING
1.	Maximum power (P_{max})	2.4 W
2.	Voltage at maximum power (V_{mpp})	12V
3.	Current at maximum power (I_{mpp})	0.2A
4.	Open circuit Voltage (V_{oc})	14.4V
5.	Short circuit current (I_{sc})	0.22A
6.	Cells	144
7.	Plug fuse rating	0.5A
8.	Array	6×4
9.	Dimension	105×60×10mm

4. Transmitting and Receiving Circuits

The transmitter circuit, shown in Fig.4 consists of an accelerometer (adxl335) which senses the displacement of made by the hand. This displacement is recorded in terms of potentials and is fed to Arduino UNO containing atmega328 microcontroller.

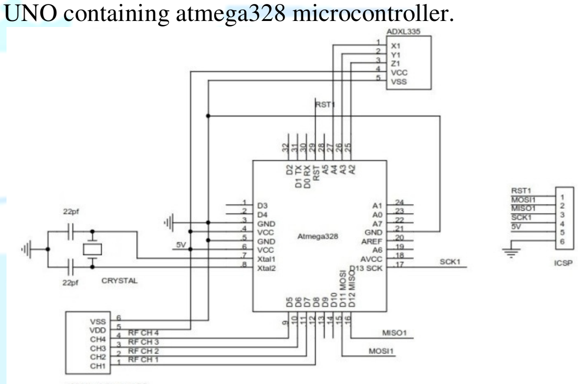

Fig. 4 Transmitter Circuit

Program based on the displacement produces the enable signals of DC motor which is on the receiver side. Now, the enable signals for the motor to rotate are ready and needs to be transmitted. Before transmitting the enable signals it needs to get encoded. Hence, HT12E encoder encodes the digital signal for transmitting. 4 channel 433 MHz RF pair is used for transmitting and receiving the radio frequency signals. This transmitter receiver module supports ASCII standard exchange of data.

The solar panel is interfaced with battery on the receiver side i.e., on the robot. As the controller remains in safer area in a room the transmitter side is powered up using an adapter or a charged battery.

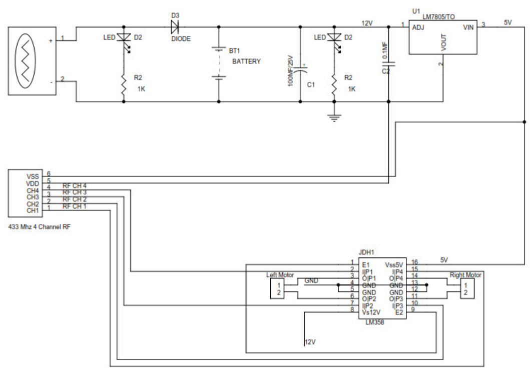

Fig.5 Receiver Circuit

The DC motors need 12V and IC chips need only 5 V hence for ICs a 7805 voltage regulator regulates the 12V potential to 5V and supplies the ICs. The circuit diagram in Fig. 4 and Fig. 5 is marked in labeling concept for clearance. A diode is placed in between battery and solar panel to prevent the back flow of current from the battery to solar panel.

5. Simulation

Solar panel simulation is done in MATLAB and Simulink, shown in Fig. 6 to obtain the VI and PI characteristics of the solar panel. The simulation is done by sensing current, voltage. The data obtained from the sensor is fed to PS-Simulink converters. This PS-Simulink converter converts the analog signals into physical data for plotting waveform and graphs. The output data of voltage and current is multiplied for obtaining the power of solar panel.

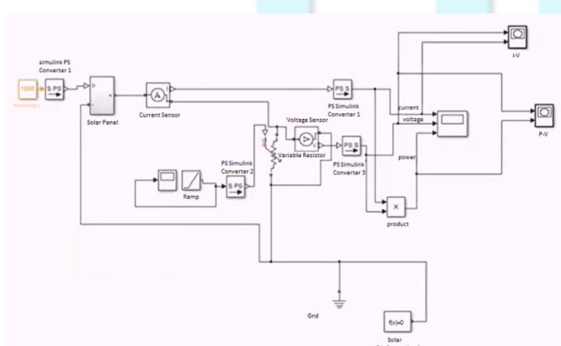

Fig. 6 Simulation of Solar Panel in MATLAB and Simulink

These obtained data are calculated by means of formulas in configurations. The waveforms are obtained in I-V and P-V scopes which are shown in Fig. 7 and Fig. 8.

The solar panel waveforms in I-V and P-V characteristics as shown in Fig. 7and Fig. 8 are obtained from the scopes P-V and I-V in Fig. 6 in which I_{max} is nearly 0.2A, V_{max} is 12V and P_{max} is 12V.

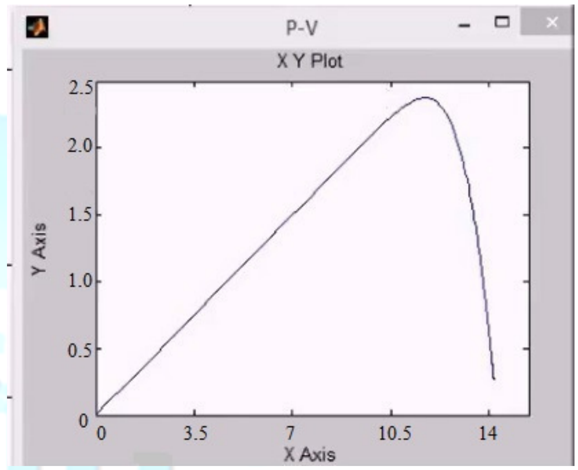

Fig. 7 Simulated Graph of PV module scope P-V (Power -Voltage characteristics)

This implies that the optimum power point of the solar panel characteristics lies at 12V, 0.2A which covers more part of region when integrated.

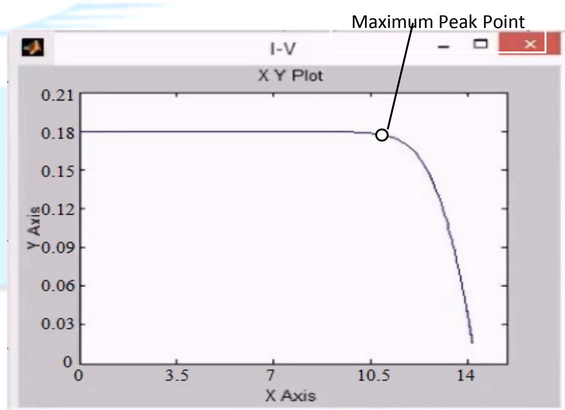

Fig. 8 Simulated Graph of PV module scope I-V (Current -Voltage characteristics)

The selection of optimum power flow point is such a way that maximum area of V-I is covered for better production of power with minimum losses.

6. Hardware Implementation

6.1) Solar Panel Charging Indication

The 12V solar panel is used to charge the battery. LED indicates the charging of the battery from the solar panel. Solar panel charges the battery, shown in Fig.9.

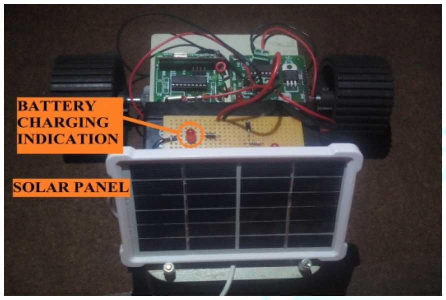

Fig 9 Battery charging LED indication from solar panel

6.2) Accelerometer adxl335

The adxl335 device is chosen as accelerometer. The x-y directions are sensed and converted as voltage potentials and are sent to Arduino UNO, shown in Fig.10.

Fig 10. Accelerometer adxl335

6.3) Arduino UNO

The Arduino UNO module receives the potentials and as per the program fed the enable signal for the motor driver is produced as 0's and 1's. this signal is fed to encoder for transmission as shown in fig 11.

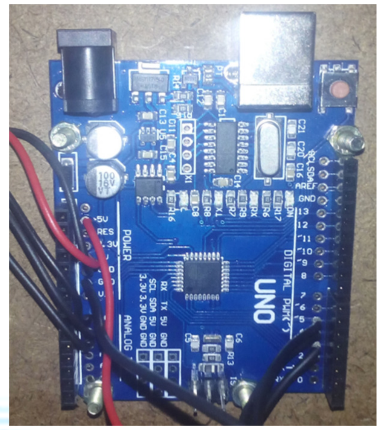

Fig 11 Arduino UNO

6.4) Encoder and Transmitter

The encoder encodes the data that it receives from the Arduino UNO for transmission. The 4 channel 433 MHz RF transmitter transmits the data with the help of antenna, shown in Fig 12.

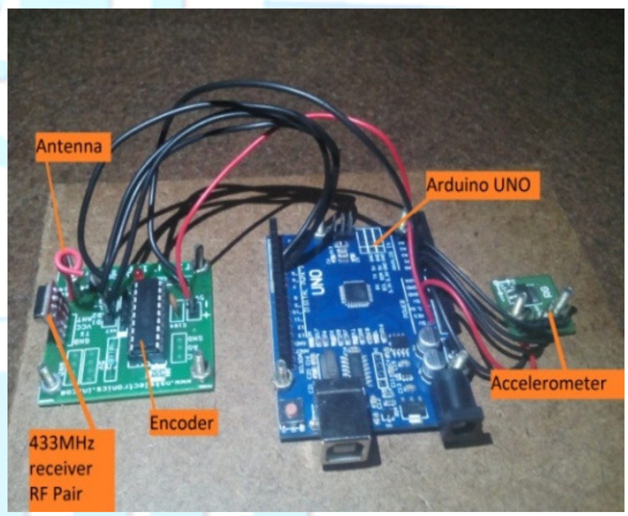

Fig 12 HT12E Encoder and 433MHz 4 Channel RF pair

6.5) Decoder and Receiver

The 4 channel 433MHz RF receiver receives the data and sends it to HT12D decoder. This decoder converts the RF signal to digital signal of 0's and 1's as shown in Fig 13.

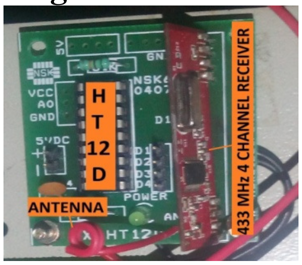

Fig 13 HT12D Decoder and 433MHz 4Channel RF Pair

6.6) Motor Driver L293D

The signals from the decoder which are programmed in transmitter Arduino UNO board is fed as enable pin command for driving the motor as shown in Fig 14

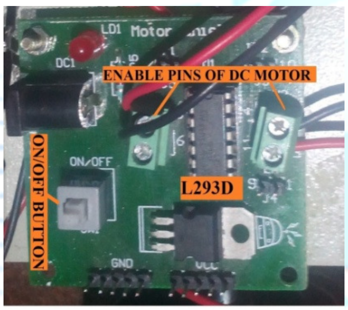

Fig 14 L293D Motor Driver

6.7) Main hardware

In the transmitting hardware shown in Fig 15 accelerometer is connected with the Arduino UNO , the signals received by the Arduino UNO are analog signals (potentials) they are converted into digital 0's and 1's.

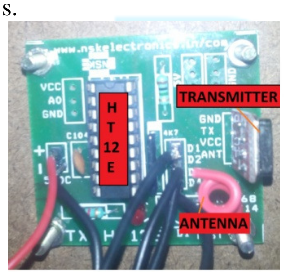

Fig 15 Transmitter circuit

Based on the 0's and 1's the commanding signal for the DC MOTOR drive is programmed here.

To transmit it the digital signals need to be encoded. Hence HT12E encoder encodes the data and transmits it via transmitter (433 MHz 4 Channel RF pair) with the help of an antenna. The receiver circuit receives the signal via antenna which is controlled by RF pair and decodes it with the help of HT12D decoder. This is directly given to the enable pins of motor driver L293D. Solar panel 12V rated is fitted to charge the battery based on the consumption of the DC motor, charging time, draining time of the battery.

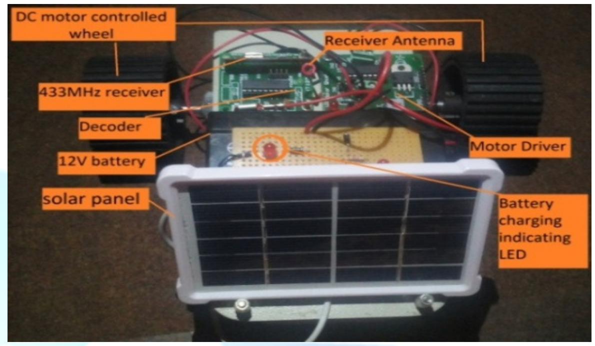

Fig 16 Receiving Hardware

The remaining IC's are supplied with the help of a LM7805 voltage regulator. Before regulation the supply is taken and is fed to the DC motors as shown in the Fig 16.

7. Conclusion

The purpose of this project is to introduce the utilization of renewable energy in the field of robotics. The output of the hardware is verified by measuring the required voltage levels at right time in multimeter. Robotics will be the upcoming generation's dream and utilizing a costless energy for powering it will be helping more to their generation. In order to save devasting fossil fuels the utilization of renewable energy will be in a good aspect. The robot's major consumer are the two DC motors hence their wanted Wattage levels, charging, discharging of battery, effieciency of solar panel were tested in the hardware shown in Fig 15 and Fig 16.

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