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Dual Axis Solar Tracking System using Arduino Uno Controller

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ABSTRACT

In this paper, solar energy is most and unlimited natural resource. Sun is the supreme sources of power to be generated to use sun power, sun tracking system to improve the energy generation of the solar panel efficiency. It is design and implementation on expert type of controller and sensors. A Light-Dependent Resistor (LDR) is used to measure, approximately, the irradiance incident on the PV array. Experimental tests are executed using an Arduino board. The proposed scheme consist of zeta converter fed through by PV module for regulating the unregulated output voltage from the panel. To using the DC geared motor providing the low speed and achieve the higher torque for panel by controlling the addition of gear system. To achieve the optimal sun tracking on the system to implement the fuzzy logic algorithm is developing the system is always solar panel face to the sun in all day time.

Keywords— *PV (Photo Voltaic)panel, ZETA (Zero Energy Thermonuclear Assembly), FLC (Fuzzy Logic Control), LDR(Light Depending Resister), Arduino Controller, etc.*

I. INTRODUCTION

Nowadays the renewable energy has received much attention due to the concerns about the environment. Among a verity source of renewable energy, solar energy is gaining the most important source. Solar energy is the very large renewable source of energy. The power from the sun is intercepting by the earth is approximately 1.8*1012MW. This energy released into space primarily as electromagnetic radiation [1]. This radiation as heat and light. It is to utilizing the maximum solar energy is based on the automatic dual axis sun tracking system. In solar application to tracking the sun to have many advantages, such obtain a large energy absorbed, operate maximum energy, most efficiency and power quality [2]. Moreover, using the zeta converter has received variable dc voltage from the solar cell to regulate the constant output voltage without any ripple content [3]. The major objective of the power interactive grid connection for solar power generation system. Which are solar panel connected in either series or parallel [1]. A zeta converter is fourth order DC-DC converter made consist of two inductors and two capacitor it will operate either step-up or step-down process. Zeta converter provide the regulating the output voltage from input voltage that deviation [3]. It is also derived from the sepic and buck-boost converter to operating in non-inverting mode. Benefit is include over output voltage without ripple. It can operate the input in buck-boost-buck and output is boost-buck-boost. It is also boost converter topology and it has operation of converter is design by continuous conduction mode (CCM) [3]. It has control the DC geared motor by using the Arduino

Uno controller for high speed operation and more accuracy. It has a very portable size and low power consumption device [6] [4]. We will be using Arduino Uno as our main board and sensors will collect the real time data from environment and it will be fetched through Fuzzy logic controller (FLC). To learn how to program in language like open source language. It widely used in general purpose, high level programming language. It has support the multiple programming paradigms and functional program [7]. Fuzzy logic control (FLC) controller is using the fuzzy logic concepts to compute the control action. It resembles human decision making with an ability to generate the precise solution from certain or approximate information [7]. It can using the membership function from the different values of Light Depending Resister (LDR) sensors [8]. So it can be reduce the power consumption of the motor .The important factor is to rotation of the panel driven by the motor driver with the help of the DC geared motor using Fuzzy logic controller to tilt precision direction. It is extension of DC motor. Which DC gear motor is to assembly with the gear attached inside the motor .The speed of the motor is counted by the rotation of shaft per minutes and is terms of RPM. The geared assembly help of to increase the torque and reduce the speed. However the large gear will be give more torque [6]. So it can easy to rotate the solar panel where desirable direction. From the experimental results, the proposed tracking system is verified more efficiency in generating energy than the fixed system.

II.SOLAR CELL DESCRIPTION

When the solar cell consist by the semiconductors of P-N junctions. It converting the solar energy into electrical energy by means of solar cell. Photovoltaic panel consist of the group of solar cells. The solar cells are predominantly made from silicon semiconductor. It have two type of p-type (positive charge) and n-type (negative charge). When a light on semiconductor the electric field across the function between these two layers cause an electric current. The greater the intensity of the light the greater flow of electricity.

The current supply I_{ph} represents the electric current generated from the sun beaming on the solar cell. R_I is the non-linear impedance of the P-N junction. D_I is a P-N junction diode, R_{sh} and R_S represent the equivalent lineup with the interior of the materials and connecting resistances in series. Usually in general analysis, Rsh is large, and the value of Rs is small. Therefore in order to simplify the process of analysis, one can ignore Rsh and R_s. The symbol Ro represents the external load. I and V represent the output current and the voltage of the solar cell, respectively.

From the equivalent circuit, and based on the characteristics of the P-N junction, (1) presents the connection between the output current I and the output voltage V**:**

$$I=n_pI_{ph}-n_pI_{sat}\,[\exp(qV/kTAn_S)-1],$$

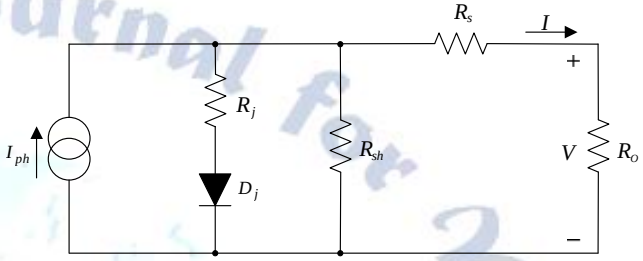


Fig.1: Equivalent circuit of solar cell

where n_P represents the parallel integer of the solar cell; n_s represents the series connected integer of the solar cell; q represents the contained electricity in an electro (1.6×10^{-19} Columbic); k is Boltzmann constant ($1.38\times10^{-23}J/°K$); T is the temperature of the solar cell (absolute temperature $°K$); and A is the ideal factor of the solar cell (A=1~ 5). The current I_{sat} in (1) represents the reversion saturation current of the solar power. Further, I_{sat} can be determined.

It is defined as electron gets ejected from the conduction band as a consequence of the absorption of sun light at a certain wave length. The absorber energy is greater than the band gap energy of the semiconductor. The electrons from the valance band jumps to conduction band. This pare of hole and electron are created in illuminated region. The conduction band are now free to move these free electrons are forced to move in a particular direction of the electric field presented in the PV cells. These flowing electron constitute current can be drawn for external use by connecting a metal plate on the bottom of PV cells, current, voltage generate electric power.

III. EXCISTING SYSTEM SEPIC CONVERTER TOPOLOGY

Circuit run best with a steady and specific input. Voltage regulator can be used to provide a reference voltage. All DC-DC converter operate by rapidly turning on and off MOSFET, generally with a high frequency pulse. What the converter does as a result of this is what make the SEPIC converter

superior. For the SEPIC, when the pulse is high the MOSFET is on, inductor 1 is charged by the input voltage and inductor 2 is charged by the capacitor 1. The diode is off and the output is maintained by the capacitor2. And it will take the duty cycle of the switch. The single-ended primary-inductor converter (SEPIC) is capable of operating from an input voltage that is greater or less than the regulated output voltage. Aside from being able to function as both a buck and boost converter, the SEPIC also has minimal active components, a simple controller, and clamped switching waveforms that provide low noise operation.

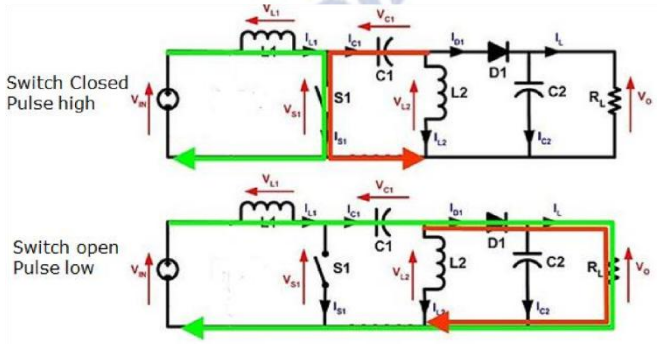


Fig. 2: Sepic converter modes of operation

When the pulse is low the MOSFET is off, inductors output through the diode to the load and the capacitors are charged. The greater the percentage of time (duty cycle) the pulse is low, the greater the output will be. This is because the longer the inductor charge, the greater the voltage will be. However, if the pulse lasts too long, the capacitor will not be able to charge and the converter will fail as shown in fig 1.1 Sepic converter can be mixing the some ripple content from the output voltage. It has only that require the one inductor and a capacitor. However that converts the suffer from the higher amount of input current ripple. This ripple can create the hormonics.so the sepic converter is inefficient. Another issue that can complicate the usage of sepic converter is the fact that they inverter the voltage sepic converter operation cause large amount of electrical stress on the component, this can result in converters can failure or overheating. And they had mentioned that the conventional SEPIC converter needs capacitance with high value and high current handling capacity. The bulk inductor has been used in SEPIC converter, so it is increase the component size and reduce the speed response. Zeta converter solve this both problems to give constant output voltage reduce the size as well as to reduce the pulsating output current.

IV. PROPOSED SYSTEM

A. *Zeta converter*

Diode and Voltage Bridge are useful for reducing the voltage by a set amount, but can be insufficient. Voltage regulators can be used to provide a reference voltage. Additionally, battery decrease as discharge which can cause many problems if there is no voltage control. The most efficient method of regulating voltage through a circuit is with a dc-dc converter. The zeta converter is comprises of a switch, a diode, two capacitors C1 and C2, two inductors L1 and L2 and a standard resistive load. The operation of zeta converter is act as a Continuous Conduction Mode (CCM). It has a forth order nonlinear system being that, with regard to energy input.

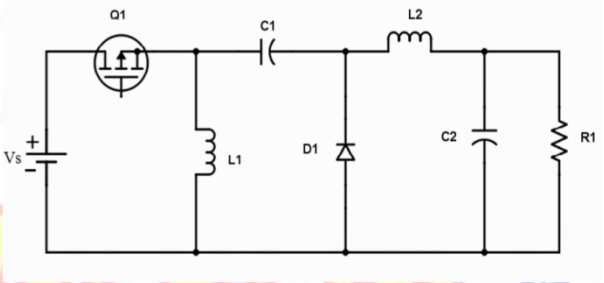


Fig.3: Zeta converter topology

B. *Modes of Operation*

MODE 1:

When the switch is ON and instantaneously, the diode D is OFF and it has reversed biased. This period current through the inductor L1 and L2 are shown from the voltage source VS. So this mode is charging mode. Also, discharging of C1 and charging of C2 take place.

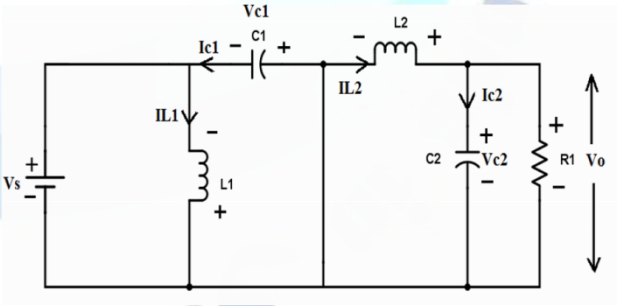


Fig.5: Equivalent circuit of zeta converter (switch ON)

By Kirchhoff's voltage law,

$V_S = L1 * di_{L1}/dt$

$$di_{l2}/dt = (v_S / L_2 + V_{C1}/L_2) - V_{C2}/L_2$$

By Kirchhoff's current law,

$$C_2 * dV_{C2}/dt = i_{L1}$$

MODE 2:

When the switch is OFF and the diode D is ON position and it has forward biased. This mode of operation is called as discharging mode. During this interval, previously charged inductor L1 starts to discharged through capacitor C1 and C2. All energy stored in L2 is transferred to the load R.

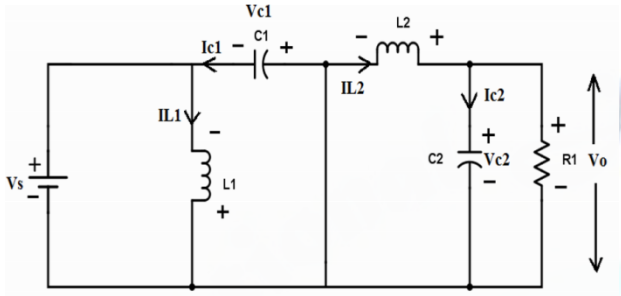


Fig.4: Equivalent circuit of zeta converter (switch OFF)

By Kirchhoff's voltage law, voltage across inductor (L1) is given by,

$L_1 \, dI_{L1}/dt = -V_1$

Voltage across the inductor L_2 is given by,

$L_2 \, di_{L2}/dt = -V_{L2}$

C. *MATLAB simulation for zeta converter*

Below is the Simulink model zeta converter for closed loop system.

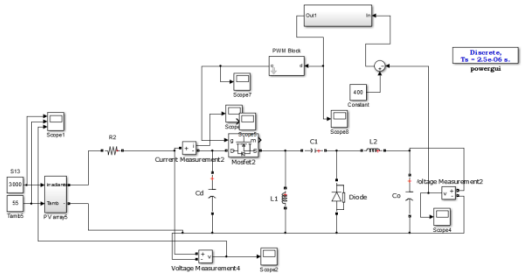


Fig.6: Simulink model for zeta converter

MATLAB simulation output waveform for ZETA converter shown below.

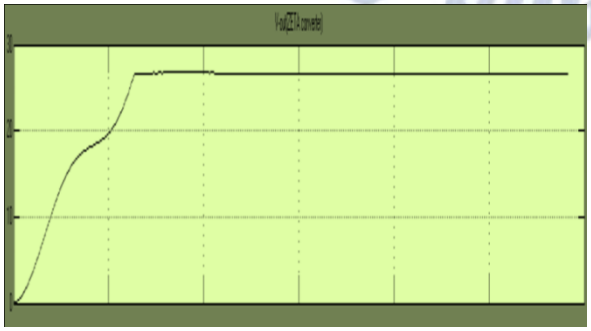


Fig.7: Output waveform for zeta converter

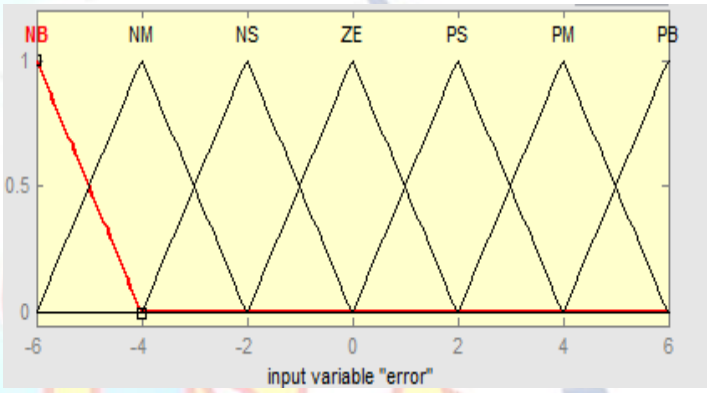
V. DESIGN METHODOLOGY

A.Fuzzy for zeta converter

Fuzzy logic controller (FLC) measures the value of voltage and current at the output of the zeta converter and then calculates the $\frac{V_{out}}{V_{in}} = \frac{1}{1-D}$

Where Error *E (k)* shows that whether at the instant *(k)* the operating point is on the zeta in characteristic curve and Change in Error *CE (k)* determines the direction in which the zeta output variables.

FLC has been designed in MATLAB following are the membership function defined MATLAB for E, CE, OUTPUT.



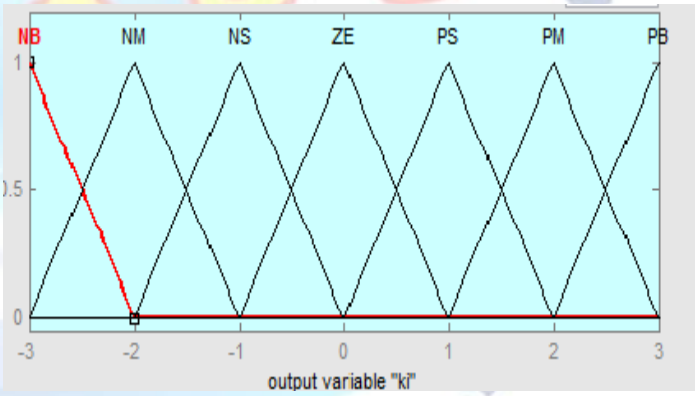


Fig.9: Shows the 7 triangular membership function for duty cycle output with all the Fuzzy sets.

CE / E	NB	NM	NS	ZE	PS	PM	PB
NB	ZE	ZE	ZE	NB	NB	NB	NB
NM	ZE	ZE	ZE	NM	NM	NM	NM
NS	NS	ZE	ZE	NS	NS	NS	NS
ZE	NM	NS	ZE	ZE	ZE	PS	PM
PS	PM	PS	PS	PS	ZE	ZE	PS
PM	PM	PM	PM	PM	ZE	ZE	ZE
PB	PB	PB	PB	PB	ZE	ZE	ZE

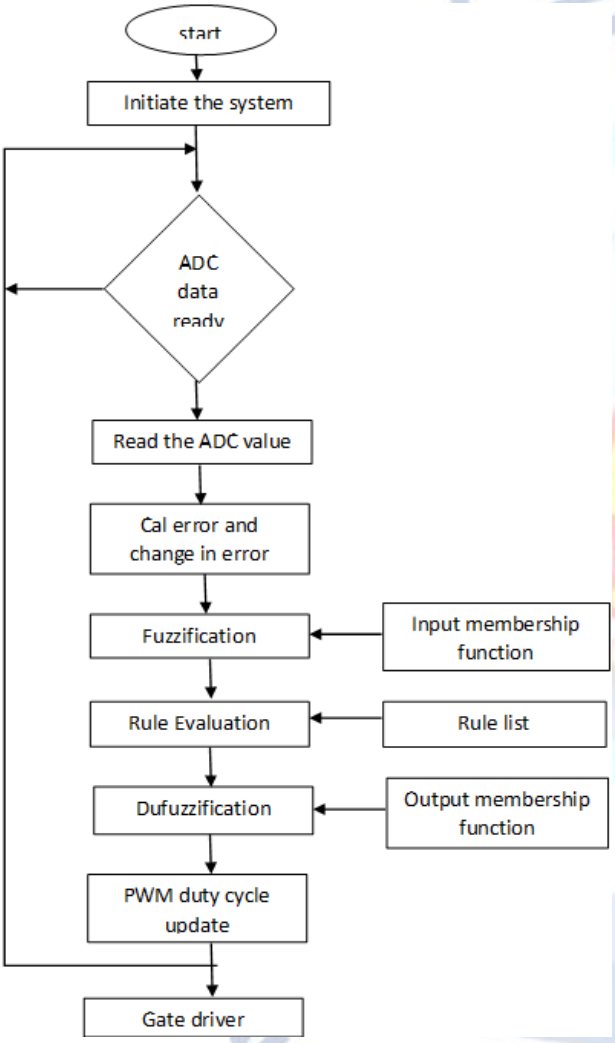
Table.1: Shows the control rule base for zeta.

Defuzzification: It is carried out by center of gravity method for determining the output of the FLC i.e.

Duty Cycle (D): $D = \frac{\sum_{j=1}^{n} \mu\,(dj) * dj}{\sum_{j=1}^{n} \mu\,(dj)}$

B. *Flow chart for Fuzzy Control*

To following the flowchart to determine the algorithm based on the Fuzzy logic which is used to implement the system



VI. ARCHITECTURE OF SYSTEM HARDWARE

The system is proposed by the solar tracking control system using ARDUINO UNO. Our high-performance solar tracking system has multiple function and uses two motors as the drives source. One of our key modules is the sun sensor. Because the sensor track the solar light sources orientation, selecting the right tracking sensor is very important. CdS sensors are very cheap, reliable, and photo sensitive. In our design. The CdS sensor provide the following advantages:

1. Without polarity (ohmic structure), CdS sensor is easy to use.
2. CdS sensors have a photo variable resister in which the internal impedance changes with the intensity of light energy.
3. When the ambient light brightens, the CdS sensor's internal impedance reduces.

The feedback signal is produced by the LDR (Light Depending Resister) fetch to fuzzy logic controller. Which is a superset of conventional (BOOLEAN LOGIC) that has been extended to handle the concept of partial truth-truth value between "completely true" and "completely false". In this output value is passing through the ARDUINO UNO controller to produce output pulse (PWM signal) for motor driver circuit to operate desired direction and solar cell is to face the sun.

A.*Solar tracking system*

For the dual axis solar tracking system, DC geared motor is used as a driving source to rotate the solar panel in the direction of the sun. the position of the sun is determine by the a solar tracking sensor like as LDR, the LDR reading output value is passing through to ADC which are analog input value(LDR) is converted into the digital signal and it is passing onto fuzzy logic controller for aligning the panel in the direction of the sun. The fuzzy control output is connected to the driver of the DC geared motor to rotate the panel through a gear system.

B.Sensor circuit and design

The tracking device is composed of four same CdS (Cadmium Sulfide) light sensitive resistors, which detect light intensity from eastern, western, southern, and northern directions, respectively. In every direction, there is a CdS light sensitive resistor with to face a light source. LDR operates on 5V DC supply. The four sensors are separated as two groups. One is using two CdS light sensitive resistors to be an eastward-westward direction sensor for comparing the light intensity of eastward and westward directions. When the eastward-westward direction sensor receives different light intensity, the system will obtain the signal according to the output voltages of the eastward-westward direction sensors. A voltage type analog/digital converter (ADC0804) can read different output voltages of the sensor and decide which direction has larger light intensity than the other direction. Then, the system will drive the DC geared motors to make the solar panel turn to the decided direction. When the output voltages of the eastward-westward direction sensor are equal, i.e.,

the difference between the outputs of the eastward-westward direction sensors is zero. Then, the motor voltage is also zero. This means that the tracking process is completed in the eastward-westward direction. Similarly for another southern-northern direction sensors. The error calculated through both the LDRs is fed to the using microcontroller as input voltage. It can be analysis by the same methodology to track the sun in the southern-northern direction.

C.DC geared motor Driver

A gear motor can be either an AC or a DC electric motor. Most gear motors have an output of between about 1200 to 1300 revolutions per minute (RPMs). It is extension of dc motor which already had inserted. A geared dc motor has assembly attached motor. The speed of the motor counted in terms of rotation of shaft per minute and in terms RPM (Revolution per minute). The geared assembly help of increase torque and reducing speed. Using correct combination of gear in gear motor, it is speed can be reduced to any desirable figure.

This concept where gear reduce the speed of vehicles but increase if torque is known as gear reduction.

D.Fuzzy logic for solar tracking

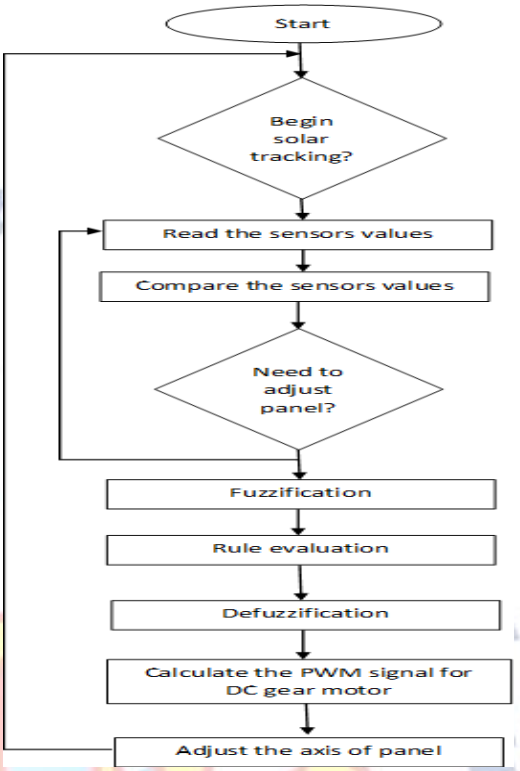
For tracking the sun to using the four LDR sensors. But fuzzy logic control to take two inputs values. Error and Change in error and gives output is one which is fed to the DC gear motor. It control the directions of rotation and speed of the DC gear motor.

Error E=Voltage (LDR_1-LDR_2)
Change in Error CE= Error – Previous Error

If the Error is positive and the Change in Error is negative then this means that the response is following the right direction and it should move forward in this direction but if the Error becomes negative and the Change in Error is negative, this implies that the response is following the wrong direction and it should start moving in the opposite direction until the panel faces the sun.
FLC has been designed in LXK Proteus 7.7 SP2 to showing the figure.

E.Flow chart for solar tracking algorithm

The below flowchart in fig. explains the algorithm used fo fuzzy based control of the sun tracking system.



VIII. ARDUINO UNO CONTROLLER

The Arduino Uno shown in fig. is a microcontroller board based on the Atmega 328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller. Simply connect it to a computer with a USB cable or power it with an AC-to-AC adapter or battery to get started.

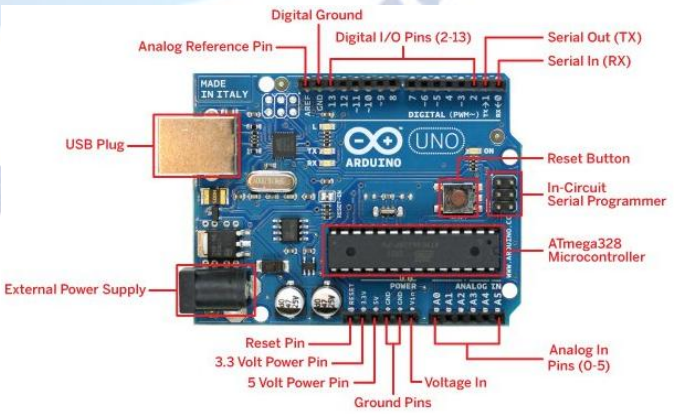


Fig.10: Diagram for Arduino Uno Controller

Arduino Uno has open source software that is easy to implement the control logic on the microcontroller board. Following table shows some specification of the microcontroller board.

Table.2: Specification of Arduino Uno Board

Microcontroller	Atmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (Atmega328) of which 0.5 KB used by boot loader
SRAM	2 KB (Atmega328)
EEPROM	1 KB (Atmega328)
Clock Speed	16 MHz

IX. CONCLUSION

DC gear motor is used for control the rotation of solar panel. It gives a precise position control and tracked efficiently throughout the day with the change in sun panel position. It is also to improve the efficiency of output power.

Fuzzy logic demonstrates efficient control, faster response and good conversion of human operator knowledge. It has also shown a better result over the conventional methods. Arduino Uno turned out to be an easy platform implement the control strategy. In this project has increased the energy generation of the solar system by using the dual axis solar tracking system.

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