Solar Inverter with Microcontroller Based Tracking System

Dip Narayan Sarkar[1], Aranya Bagchi[2], Soham Mohanti[3], Mrinmoy Patra[4], Shaon Paul[5]

Abstract— *Sunlight is the basic source for the generation of solar energy for producing electricity. Here sunlight is being harnessed to produce solar energy along with the use of inverter circuit. Sunlight, falling on solar array made up of silicon material, is basically a semiconductor. The solar array is being rotated with the help of a stepper motor according to certain delay of time using microcontroller. The microcontroller which is used belongs to AVR family of microcontroller.*
Light having photon, energize the semiconductor which breaks the forbidden energy gap of semiconductor and electron are made to excite from valance band to conduction band, causing the *current to flow. This D.C power is directly fed to a rechargeable battery without the use of a charge controller because of low power applications. Then this power is supplied to the inverter (dc to ac converter) which is connected to load.*

Keywords: *Photovoltaic Cell, MPPT, MOSFET, IC 555, AT Mega 16, Unipolar Stepper Motor, Driver IC.*

1 INTRODUCTION

IN today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy. Solar energy is quite simply the energy produced directly by the sun and collected everywhere on the Earth. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. The process creates heat and electromagnetic radiation. The heat remains in the sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) streams out into space in all directions. If this energy from the sun is collected then, what we are doing in this project is that to generate electricity from solar power.

As we know that solar energy is collected by the *solar collector* made up of PV module. Photovoltaic cells, by their very nature, convert radiation to electricity. This phenomenon has been known for well over half a century, but until recently the amounts of electricity generated were good for little more than measuring radiation intensity. Most of the photovoltaic cells on the market today operate at an efficiency of less than 15%. The maximum theoretical efficiency for a photovoltaic cell is only 32.3%, but at this efficiency, solar electricity is very economical. Most of our other forms of electricity generation are at a lower efficiency than this. Unfortunately, reality still lags behind theory and 15% efficiency is not usually considered economical by most power companies, even if it is fine for toys and pocket calculators. Hope for bulk solar electricity should not be abandoned, however, for recent scientific advances have created a solar cell with an efficiency of 28.2% efficiency in the laboratory.

Sunlight is made to fall on the solar array made of silicon material which is basically a semiconductor. Light having photon, energize the semiconductor which breaks the forbidden gap of the semiconductor and electrons are made to excite from valence band to conduction band, causing the current flow.

This D.C power is fed to a charge controller and then to a rechargeable battery. Then this power is supplied to inverter (dc to ac converter). L-C filter is connected to make the output ripple free. After that it is connected to the load. The solar array is being rotated with the help of a stepper motor according to certain delay of time using microcontroller.

2. DETAILS OF THE PROPOSED TECHNOLOGY

2.1 Implementation

The performance of solar power plants is best defined by the Capacity Utilization Factor (CUF), which is the ratio of the

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actual electricity output from the plant, to the maximum possible output during the year. The estimated output from the solar power plant depends on the design parameters and can be calculated, using standard softwares. But since there are several variables which contribute to the final output from a plant, the CUF varies over a wide range. These could be on account of poor selection or quality of panels, de-rating of modules at higher temperatures, other design parameters like ohmic loss, atmospheric factors such as prolonged cloud cover and mist. It is essential therefore to list the various factors that contribute to plant output variation. The performance of the power plant however depends on several parameters including the site location, solar insulation levels, climatic conditions specially temperature, technical losses in cabling, module mismatch, soiling losses, MPPT losses, transformer losses and the inverter losses. There could also be losses due to grid unavailability and the module degradation through aging. Some of these are specified by the manufacturer, such as the dependence of power output on temperature, known as temperature coefficient. The following factors are considered key performance indicators:

1. Radiation at the site
2. Losses in PV systems
3. Temperature and climatic conditions
4. Design parameters of the plant
5. Inverter efficiency
6. Module Degradation due to aging

2.2 Existing Practice

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

Input voltage:

A typical power inverter device or circuit requires a relatively stable DC power source capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter. Examples include:

- ❖ 12 V DC, for smaller consumer and commercial inverters that typically run from a rechargeable 12V lead acid battery.
- ❖ 24 and 48 VDC, which are common standards for home energy systems.
- ❖ Hundreds of thousands of volts, where the inverter is part of a High voltage direct current power transmission system.

Output waveform:

An inverter can produce a square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design. The two dominant commercialized waveform types of inverters as of 2007 are modified sine wave and sine wave.

There are two basic designs for producing household plug-in voltage from a lower-voltage DC source, the first of which uses a switching boost converter to produce a higher-voltage DC and then converts to AC. The second method converts DC to AC at battery level and uses a line-frequency transformer to create the output voltage.

Square wave:

This is one of the simplest waveforms an inverter design can produce and is useful for some applications.

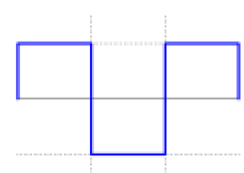

Figure 2: Square Wave

Sine wave:

A power inverter device which produces a multiple step sinusoidal AC waveform is referred to as a *sine wave inverter*. To more clearly distinguish the inverters with outputs of much less distortion than the "modified sine wave" (three step) inverter designs, the manufacturers often use the phrase *pure sine wave inverter*. Almost all consumer grade inverters that are sold as a "pure sine wave inverter" does not produce a smooth sine wave output at all, just a less choppy output than the square wave (one step) and modified sine wave (three steps) inverters. In this sense, the phrases "Pure sine wave" or "sine wave inverter" are misleading to the consumer. However, this is not critical for most electronics as they deal with the output quite well. When power inverter devices are substituted for

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standard line power, a sine wave output is desirable because many electrical products are engineered to work best with a sine wave AC power source. The standard electric utility power attempts to provide a power source that is a good approximation of a sine wave.

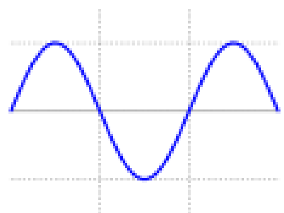

Figure 3: Sine Wave

Modified sine wave:

A "modified sine wave" inverter has a non-square waveform that is a useful rough approximation of a sine wave for power translation purposes.

The waveform in commercially available modified-sine-wave inverters is a square wave with a pause before the polarity reversal, which only needs to cycle back and forth through a three-position switch that outputs forward, off, and reverse output at the pre-determined frequency. Switching states are developed for positive, negative and zero voltages as per the patterns. The peak voltage to the RMS voltage does not maintain the same relationship as for a sine wave. The DC bus voltage may be actively regulated or the "on" and "off" times can be modified to maintain the same RMS value output up to the DC bus voltage to compensate for DC bus voltage variation.

The ratio of on to off time can be adjusted to vary the RMS voltage while maintaining a constant frequency with a technique called PWM. The generated gate pulses are given to each switch in accordance with the developed pattern and thus the output is obtained. Harmonic spectrum in the output depends on the width of the pulses and the modulation frequency. When operating induction motors, voltage harmonics are not of great concern; however, harmonic distortion in the current waveform introduces additional heating and can produce pulsating torques.

Numerous electric equipments will operate quite well on modified sine wave power inverter devices, especially any load that is resistive in nature such as a traditional incandescent light bulb. Most AC motors will run on MSW inverters with an efficiency reduction of about 20% due to the harmonic content. However, they may be quite noisy. A series LC filter tuned to the fundamental frequency may help.

Output frequency

The AC output frequency of a power inverter device is usually the same as standard power line frequency, 50 or 60 hertz.

If the output of the device or circuit is to be further conditioned (for example stepped up) then the frequency may be much higher for good transformer efficiency.

2.3 Apparatus and Componants Details

Different components and apparatus are used while making of this project. The list of components and apparatus required are listed below:

COMPONENTS USED:

a. IC 555 timer, b. 2 MOSFETs of IRF540N, c. Transistor BC549, d. Centre Tap Transformer of 220V, 50Hz, e. Resistors of 1K(2pcs), 4.7K, 120K, 5.6K, f. 2pcs Capacitors of 0.1 microfarad, g. Solar Charge Controller Battery of 12V, h. ULN2003 Driver I.C., i. 4pcs of Capacitors of 22 pF, j. Unipolar Stepper Motor of 5V, k. Veroboard (5*5").

APPARATUS REQUIRED:

Cutter, Multimeter, Soldering iron, Multi core wire

Here for rotating the solar panel or solar array, microcontroller programming is being used. ATMega16 belongs to the family of AVR microcontroller. While discussing the operation of stepper motor, ATMega16 will be discussed there.

I.C. 555 Timer

Introduction

The 555 timer IC was introduced in the year 1970 by Signetic Corporation and gave the name SE/NE 555 timer. It is basically a monolithic timing circuit that produces accurate and highly stable time delays or oscillation. When compared to the applications of an op-amp in the same areas, the 555IC is also equally reliable and is cheap in cost. Apart from its applications as a monostable multivibrator and astable multivibrator, a 555 timer can also be used in dc-dc converters, digital logic probes, waveform generators, analog frequency meters and tachometers, temperature measurement and control devices, voltage regulators etc. The timer IC is setup to work in either of the two modes – one-shot or monostable or as a free-running or astable multivibrator. The SE 555 can be used for temperature ranges between 55°C to 125°. The NE 555 can be used for a temperature range between 0° to 70°C.

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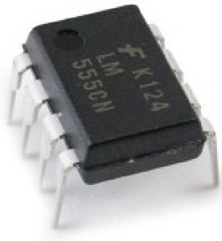
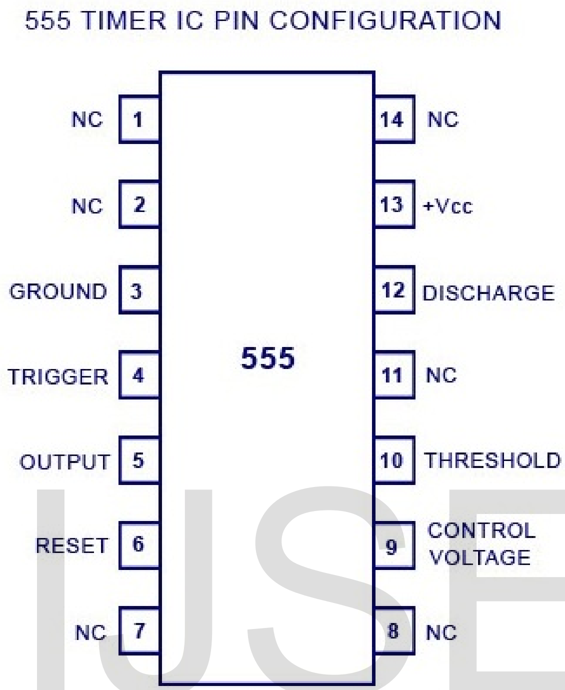
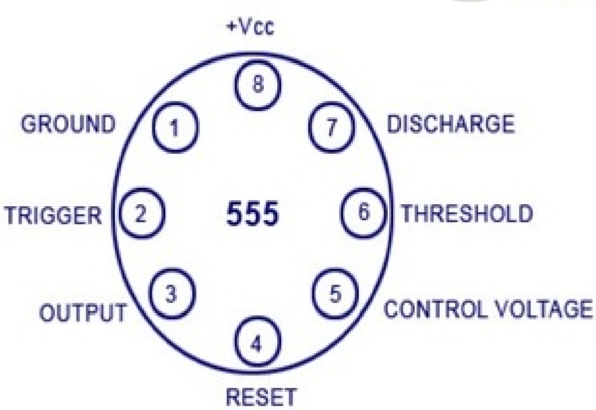


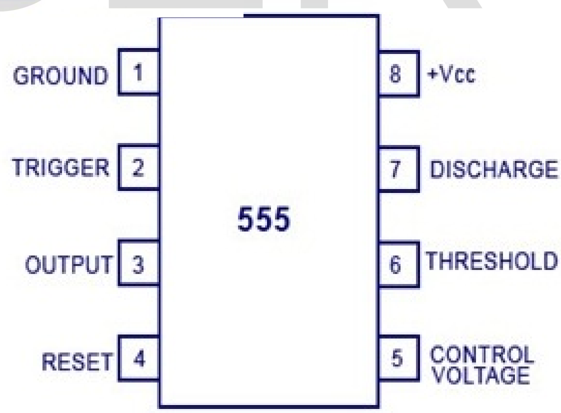
The important features of the 555 timer are:

- It operates from a wide range of power supplies ranging from + 5 Volts to + 18 Volts supply voltage.
- Sinking or sourcing 200 mA of load current.
- The external components should be selected properly so that the timing intervals can be made into several minutes along with the frequencies exceeding several hundred kilo hertz.
- The output of a 555 timer can drive transistor-transistor logic (TTL) due to its high current output.
- It has a temperature stability of 50 parts per million (ppm) per degree Celsius change in temperature, or equivalently 0.005 % per °C.
- The duty cycle of the timer is adjustable.
- The maximum power dissipation per package is 600 mW and its trigger and reset inputs have logic compatibility. More features are listed in the datasheet.





Top View Of Metal Can Package



8-Pin DIP

Working Principle

Referring to the block diagram of 555 timer IC shown above, the internal resistors act as a voltage divider network, providing (2/3)Vcc at the non-inverting terminal of the upper comparator and (1/3)Vcc at the inverting terminal of the lower comparator. In most applications, the control input is not used, so that the control voltage equals +(2/3) V_{CC}. Upper comparator has a threshold input (pin 6) and a control input (pin 5). Output of the upper comparator is applied to set (S) input of the flip-flop. Whenever the threshold voltage exceeds the control voltage, the upper comparator will set the flip-flop and its output is high. A high output from the flip-flop when given to the base of the discharge transistor saturates it and thus discharges the transistor that is connected externally to the discharge pin 7. The complementary signal out of the flip-flop goes to pin 3, the output. The output available at pin 3 is low. These conditions will prevail until lower comparator triggers the flip-flop. Even if the voltage at the threshold input falls below (2/3) V_{CC}, i.e., upper comparator cannot cause the flip-flop to change again. It means that the upper comparator can only force the flip-flop's output high.

To change the output of flip-flop to low, the voltage at the trigger input must fall below +(1/3)Vcc. When this occurs, lower comparator triggers the flip-flop, forcing its output low. The low output from the flip-flop turns the discharge transistor off and forces the power amplifier to output a high. These conditions will continue independent of the voltage on the trigger input. Lower comparator can only cause the flip-flop to output low.

From the above discussion it is concluded that for the having

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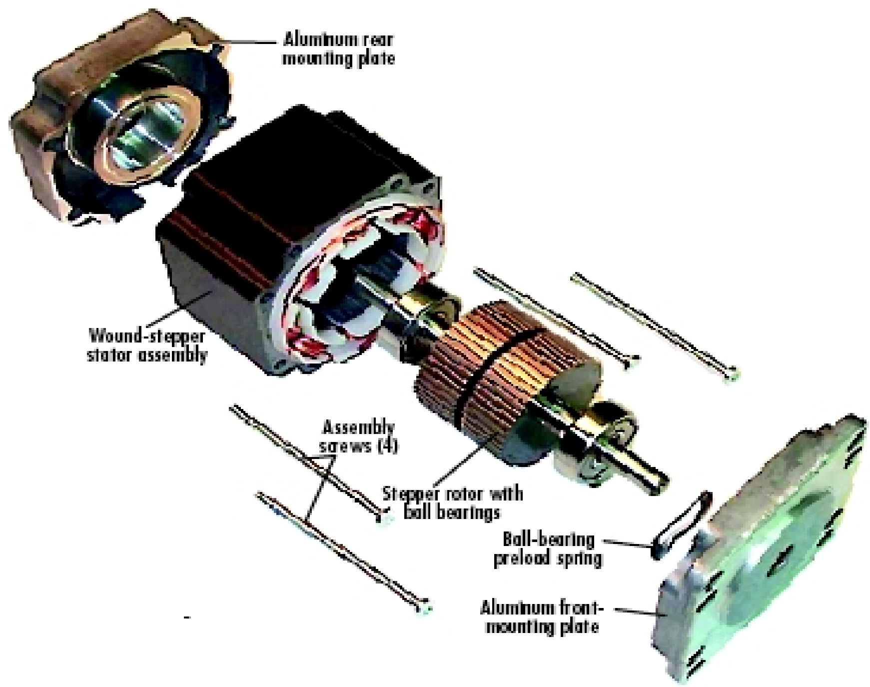
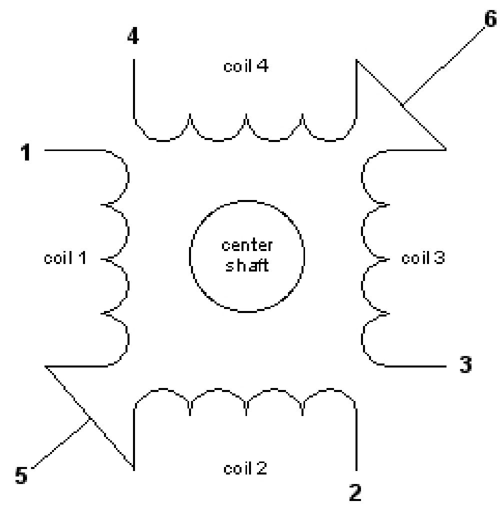




low output from the timer 555, the voltage on the threshold input must exceed the control voltage or +(2/3) V_{CC}. This also turns the discharge transistor on. To force the output from the timer high, the voltage on the trigger input must drop below +(1/3) V_{CC}. This turns the discharge transistor off.

A voltage may be applied to the control input to change the levels at which the switching occurs. When not in use, a 0.01 nanoFarad capacitor should be connected between pin 5 and ground to prevent noise coupled onto this pin from causing false triggering.

Connecting the reset (pin 4) to a logic low will place a high on the output of flip-flop. The discharge transistor will go on and the power amplifier will output a low. This condition will continue until reset is taken high. When it is not in use, reset should be tied to +V_{CC}.

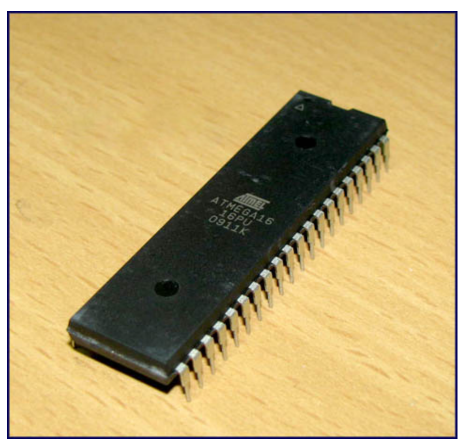
Stepper Motor Control Using ATMEGA-16 Microcontroller

A stepper motor is a brushless, electric motor that can divide a full rotation into a large number of steps. It works on the principle of electromagnetism. There is a magnetic rotor shaft of soft iron which is surrounded by the electromagnetic stators. Depending on the type the stepper motor may be teethed or non-teethed rotor and stator. When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of variable reluctance stepper). In this way the stators are energized in a sequence to rotate stepper motor. In steppe motor like and unlike poles concept is used.

Figure 7: Exploded view of Stepper Motor

Types of Stepper Motor

- Permanent Magnet Stepper Motor
- Variable Reluctance Stepper Motor
- Hybrid Stepper Motor



3. Material Description and Features

3.1 ATMEGA16's Description

ATmega16 is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. Atmega16 is based on enhanced RISC (Reduced Instruction Set Computing) architecture with 131 powerful instructions. Most of the instructions execute in one machine cycle. Atmega16 can work on a maximum frequency of 16MHz.

ATmega16 has 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 Bytes. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000, respectively.

ATmega16 is a 40 pin microcontroller. There are 32 I/O (input/output) lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD.

ATmega16 has various in-built peripherals like:
USART, ADC, Analog Comparator, SPI, JTAG
etc. Each I/O pin has an alternative task related to in-built peripherals. The following table shows the pin description of ATmega16.

Pin Diagram:

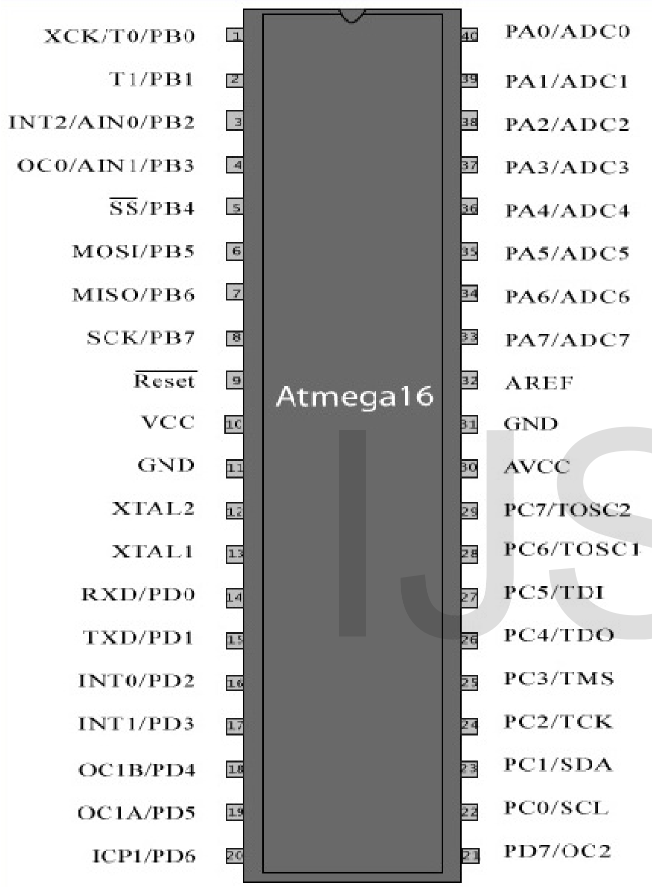


Figure 14: Pin configuration of ATMEGA-16 Microcontroller

Table 1: Pin Description of ATMEGA-16

Pin No.	Pin name	Description	Alternate Function
1	(XCK/T0) PB0	I/O PORTB, Pin 0	T0: Timer0 External Counter Input. XCK : USART External Clock I/O
2	(T1) PB1	I/O PORTB, Pin 1	T1:Timer1 External Counter Input
3	(INT2/AIN0) PB2	I/O PORTB, Pin 2	AIN0: Analog Comparator Positive I/P INT2: External Interrupt 2 Input
4	(OC0/AIN1) PB3	I/O PORTB, Pin 3	AIN1: Analog Comparator Negative I/P OC0 : Timer0 Output Compare Match Output
5	(SS) PB4	I/O PORTB, Pin 4	In System Programmer (ISP) Serial Peripheral Interface (SPI)
6	(MOSI) PB5	I/O PORTB, Pin 5	
7	(MISO) PB6	I/O PORTB, Pin 6	
8	(SCK) PB7	I/O PORTB, Pin 7	
9	RESET	Reset Pin, Active Low Reset	
10	Vcc	Vcc = +5V	
11	GND	GROUND	
12	XTAL2	Output to Inverting Oscillator Amplifier	
13	XTAL1	Input to Inverting Oscillator Amplifier	
14	(RXD) PD0	I/O PORTD, Pin 0	USART Serial Communication Interface
15	(TXD) PD1	I/O PORTD, Pin 1	
16	(INT0) PD2	I/O PORTD, Pin 2	External Interrupt INT0
17	(INT1) PD3	I/O PORTD, Pin 3	External Interrupt INT1
18	(OC1B) PD4	I/O PORTD, Pin 4	PWM Channel Outputs
19	(OC1A) PD5	I/O PORTD, Pin 5	
20	(ICP) PD6	I/O PORTD, Pin 6	Timer/Counter1 Input Capture Pin
21	PD7 (OC2)	I/O PORTD, Pin 7	Timer/Counter2 Output Compare Match Output

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22	PC0 (SCL)	I/O PORTC, Pin 0	TWI Interface
23	PC1 (SDA)	I/O PORTC, Pin 1	
24	PC2 (TCK)	I/O PORTC, Pin 2	JTAG Interface
25	PC3 (TMS)	I/O PORTC, Pin 3	
26	PC4 (TDO)	I/O PORTC, Pin 4	
27	PC5 (TDI)	I/O PORTC, Pin 5	
28	PC6 (TOSC1)	I/O PORTC, Pin 6	Timer Oscillator Pin 1
29	PC7 (TOSC2)	I/O PORTC, Pin 7	Timer Oscillator Pin 2
30	AVcc	Voltage Supply = Vcc for ADC	
31	GND	GROUND	
32	AREF	Analog Reference Pin for ADC	
33	PA7 (ADC7)	I/O PORTA, Pin 7	ADC Channel 7
34	PA6 (ADC6)	I/O PORTA, Pin 6	ADC Channel 6
35	PA5 (ADC5)	I/O PORTA, Pin 5	ADC Channel 5
36	PA4 (ADC4)	I/O PORTA, Pin 4	ADC Channel 4
37	PA3 (ADC3)	I/O PORTA, Pin 3	ADC Channel 3
38	PA2 (ADC2)	I/O PORTA, Pin 2	ADC Channel 2
39	PA1 (ADC1)	I/O PORTA, Pin 1	ADC Channel 1
40	PA0 (ADC0)	I/O PORTA, Pin 0	ADC Channel 0

3.2 Metal Oxide Semiconductor Field Effect Transistor (MOSFET)

Metal oxide semiconductor field effect transistor is capable of voltage gain and signal power gain. The MOSFET is the core of integrated circuit designed as thousands of these can be fabricated in a single chip because of its very small size. Every modern electronic system consists of VLST technology and without MOSFET, large scale integration is impossible.

It is a four terminals device. The drain and source terminals are connected to the heavily doped regions. The gate terminal is connected top on the oxide layer and the substrate or body terminal is connected to the intrinsic semiconductor.

MOSFET has four terminals which is already stated above, they are gate, source drain and substrate or body. MOS capacity present in the device is the main part. The conduction and valance bands are position relative to the Fermi level at the surface is a function of MOS capacitor voltage. The metal of the gate terminal and the sc acts the parallel and the oxide layer acts as insulator of the state MOS capacitor. Between the drain and source terminal inversion layer is formed and due to the flow of carriers in it, the current flows in MOSFET the inversion layer is properties are controlled by gate voltage. Thus it is a voltage controlled device.

Two basic types of MOSFET are n channel and p channel MOSFETs. In n channel MOSFET is current is due to the flow of electrons in inversion layer and in p channel current is due to the flow of holes.

Working Principle of MOSFET

The working principle of MOSFET depends up on the MOS capacitor. The MOS capacitor is the main part. The semiconductor surface at below the oxide layer and between the drain and source terminal can be inverted from p-type to n-type by applying a positive or negative gate voltages respectively.

When we apply positive gate voltage the holes present beneath the oxide layer experience repulsive force and the holes are pushed downward with the substrate. The depletion region is populated by the bound negative charges, which are associated with the acceptor atoms. The positive voltage also attracts electrons from the n+ source and drain regions in to the channel. The electron reach channel is formed. Now, if a voltage is applied between the source and the drain, current flows freely between the source and drain gate voltage controls the electrons concentration the channel. Instead of positive if negative voltage is applied, a hole channel will be formed beneath the oxide layer.

Now, the controlling of source to gate voltage is responsible for the conduction of current between source and the drain. If the gate voltage exceeds a given value, called the three voltages only then the conduction begins.

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N-Channel MOSFET

MOSFET having n-channel region between source and drain is known as n-channel MOSFET. It is a four terminal device; the terminals are gate, drain and source and substrate or body. The drain and source is heavily doped n+ region and the substrate is p-type. The current flows due to flow of the negatively charged electrons, that's why it is known as n- channel MOSFET. When we apply the positive gate voltage the holes present beneath the oxide layer experiences repulsive force and the holes are pushed downwards in to the bound negative charges which are associated with the acceptor atoms. The positive gate voltage also attracts electrons from n+ source and drain region in to the channel thus an electron reach channel is formed, now if a voltage is applied between the source and drain. The gate voltage controls the electron concentration in the channel n-channel MOSFET is preferred over p-channel MOSFET as the mobility of electrons are higher than holes. The diagrams of enhancements mode and depletion mode are given below.

Manufacturer	Various
Manufacturer's Part Number	IRF540
Manufacturer's Web Site	-
Futurlec Part Number	IRF540
Department	Transistors
Category	Mosfet - IRF Series
RoHS Compliant	-
Package Type	TO-220
Technical Data	IRF540 Datasheet

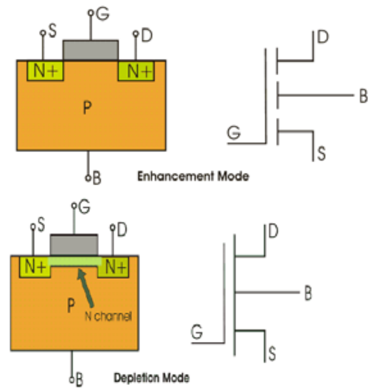

Figure 15: Depletion and Enhencement mode of n-channeMOSFET

Figure 16: IRF540 N-channel MOSFET

3.3 Transistor

A transistor is a semiconductor used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. The transistor is the key active component in practically all modern electronics.

There are two types of transistors, which have slight differences in how they are used in a circuit. A bipolar transistor has terminalslabelled base, collector, and emitter. A small current at the base terminal (that is, flowing between the base and the emitter) can control or switch a much larger current between the collector and emitter terminals. For a field effect transistor, the terminals are labelled gate, source, and drain, and a voltage at the gate can control a current between source and drain. The transistor's low cost, flexibility, and reliability have made it a ubiquitous device.

Here in this project we have used BC549 NPN General Purpose Transistor.

Features

- Low current (max. 100 mA)
- Low voltage (max. 45 V)

Application

- Low noise stages in audio frequency equi

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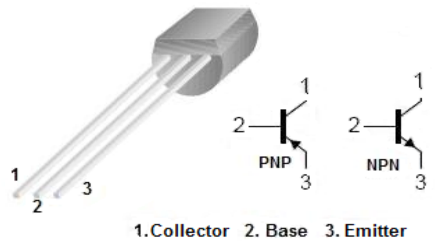

Figure 17: Pin configuration of Transistor BC549

3.4 Centre Tap Transformer

A Centre Tapped transformer works in more or less the same way as a usual transformer. The difference lies in just the fact that its secondary winding is divided into two parts, so two individual voltages can be acquired across the two line ends.

Construction

When an additional wire is connected across the exact middle point of the secondary winding of a transformer, it is called a centre tapped transformer. The wire is adjusted such that it falls in the exact middle point of the secondary winding and is thus at zero volts, forming the neutral point for the winding. This is called the “centre tap” and this thing allows the transformer to provide two separate output voltages which are equal in magnitude, but opposite in polarity to each other. In this way, we can also use a number of turn ratios from such a transformer.

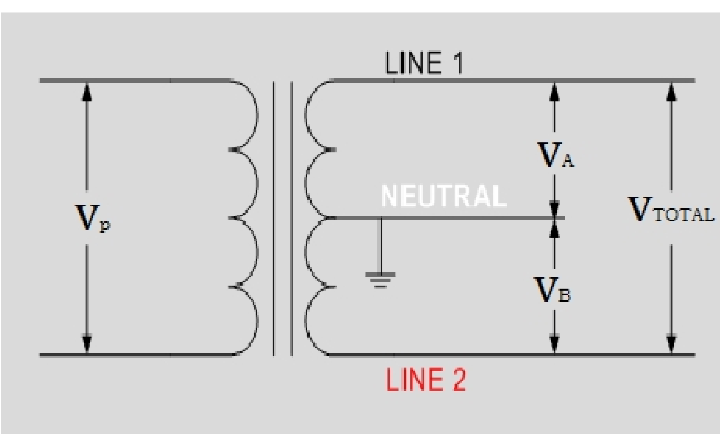

Figure 18: Circuit Diagram of Centre Tap TransformerAs it can be seen from the figure that this type of configurations gives us two phases through the two parts of the secondary coil, and a total of three wires, in which the middle one, thcentre tapped wire is the neutral one. So this centre tapped configuration is also known as a two phase- three wire transformer system.

In this way, half the voltage appears across one half of the phase, that is from line 1 to neutral, and the other half of the voltage appears across the next phase, that is from neutral to Line 2. If the load is connected directly between line 1 and line 2, then we get the total voltage, that is, the sum of the two voltages

Working of this transformer

The two voltages, between line 1 and neutral and between neutral and line 2 can be named as VA and VB respectively. Then the mathematical relation of these two voltages shows that they are dependent upon the primary voltage as well as the turn ration of the transformer.

$$V_A = (N_A / N_P) * V_P$$
$$V_B = (N_B / N_P) * V_P$$

One thing that should be noted here is that both the outputs VA and VB respectively are equal in magnitude but opposite in direction, which means that they are 180 degrees out of phase with each other. For this purpose, we also use a full wave rectifier with a centre tapped transformer, to make both the voltages in phase with each other.

Limitations

The transformer has multiple of application in rectifier but if offers its own limitation. Few limitations of centre tapped transformers are as follows:

ULN2003 Driver I.C.

The ULN2003 is a monolithic high voltage and high current Darlington transistor arrays. It consists of seven NPN Darlington pairs that features high-voltage outputs with common-cathode clamp diode for switching inductive loads. The collector-current rating of a single Darlington pair is 500mA. The Darlington pairs may be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED gas discharge), line drivers and logic buffers. The ULN2003 has a 2.7kΩ series base resistor for each Darlington pair for operation directly with TTL or 5V CMOS devices.

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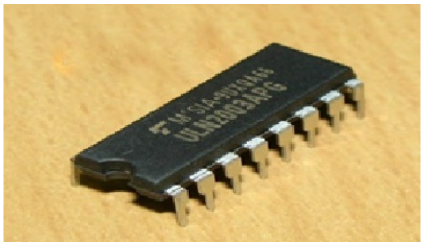
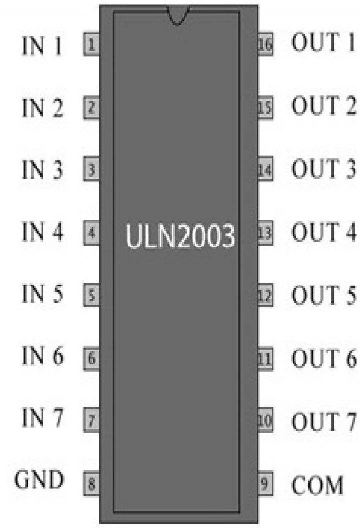


Figure 19: ULN2003 Driver I.C.

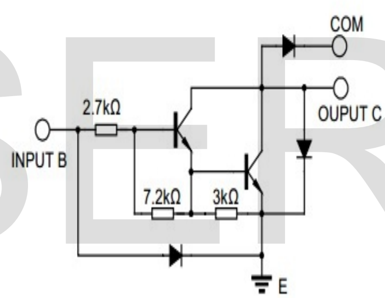
Pin No	Function	Name
1	Input for 1st channel	Input 1
2	Input for 2nd channel	Input 2
3	Input for 3rd channel	Input 3
4	Input for 4th channel	Input 4
5	Input for 5th channel	Input 5
6	Input for 6th channel	Input 6
7	Input for 7th channel	Input 7
8	Ground (0V)	Ground
9	Common freewheeling diodes	Common
10	Output for 7th channel	Output 7
11	Output for 6th channel	Output 6
12	Output for 5th channel	Output 5
13	Output for 4th channel	Output 4
14	Output for 3rd channel	Output 3
15	Output for 2nd channel	Output 2
16	Output for 1st channel	Output 1

Features

* 500mA rated collector current (Single output)
* High-voltage outputs: 50V
* Inputs compatible with various types of logic
* Relay driver application



LOGIC DIAGRAM



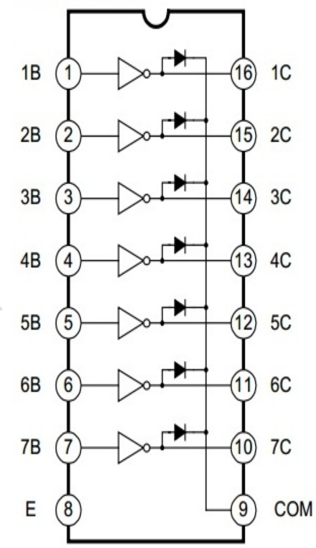


Figure 20: Logic and Schematic Diagram

Figure 21: Pin Configuration of ULN2003 Driver I.C.

Pin Diagram

4. CIRCUIT IMPLEMENTATION

4.1 Working of Inverter Circuit

This circuit is a 100 watt 220 volts power inverter circuit which is easy and small in size. Use of NE555 or I.C. 555 timer and MOSFET are the main components for making this circuit. The circuit works well when a source of 12V battery is used and will have an output of 100 watts.

Principle of the Circuit:

The Figure shown below is the complete circuit diagram of the inverter. A source of 12V battery is used to supply power through IC-NE555 timer which gives a square wave frequency generator output of 50Hz. The frequency is determined with resistor R2 and capacitor C1 which is set at 50Hz output. Using N-type MOSFET IRF540 (Q2, Q3) as driver, the primary winding of the centre tap transformer coil is connected to the drain source of Q2 and Q3. The current of Pin 3 of IC1 will flow in two ways, firstly through R3 to the gate of Q2 and, secondly it will flow to Q1-transistor BC549 as inverter logic form to reverse signal difference. Next, current will flow to the gate of Q3 to drive the transformer.

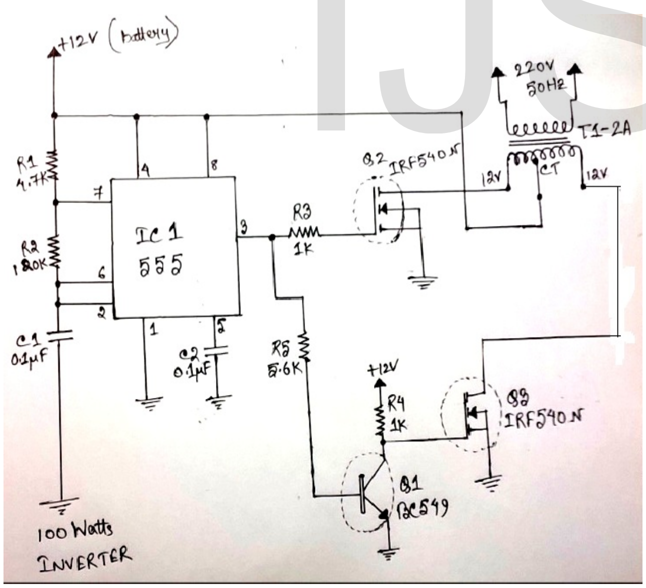


Figure 26: Circuit diagram of Inverter

The transformer used is of 2A current, 12V input and at the output, power is more than 100 watts. Selection of IRF540 is because it's cheaper and can be used for N-CHANNEL POWER MOSFET, 100V, 27A, TO-220 easy to mount over heat sink and easy to use than power transistor. We can use smaller heat sink than a transistor, if not too heated.

4.2 Stepper Motor Circuit

Interfacing of Stepper Motor with Microcontroller

We have already discussed about the stepper motor in details in section 3.2.2. Now we will discuss about the connection of Unipolar Stepper Motor using ULN2003 as in this project we have used Unipolar Stepper Motor for rotating the solar array. Also the algorithm to interface stepper motor with microcontroller is explained with the circuit diagram.

Connecting unipolar stepper motor using ULN2003:

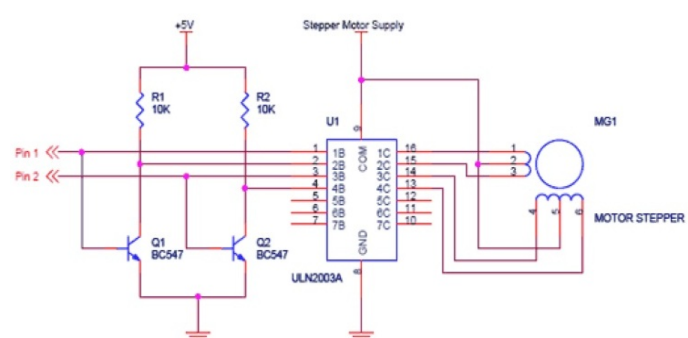
Here in this circuit the four pins "Controller pin" 1, 2, 3 and 4 will control the motion and direction of the stepper motor according to the step sequence sent by the controller.

Figure 27: Unipolar Stepper with ULN2003

Algorithm to interface Stepper Motor with Microcontroller:

1) The first four input pins (1B4B) of the motor driver ULN2003 is connected with the PORTD of MCU (PD0PD3).
2) The Stepper motor is connected with the ULN2003 output pins (1C3C).
3) 12V power supply is given to the driver.
4) Initialize the motor driver.
5) The motor driver takes the input from the microcontroller PORTD.
6) The driver runs the motor according to the requirement ither in clockwise or in anti clockwise.

The Circuit Diagram is shown below.



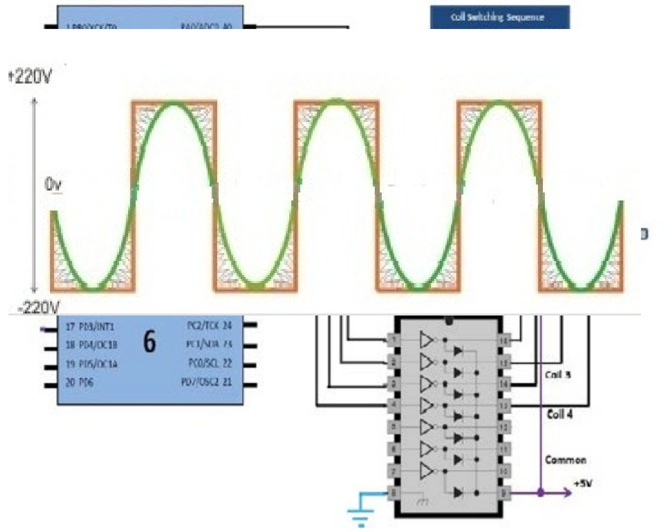
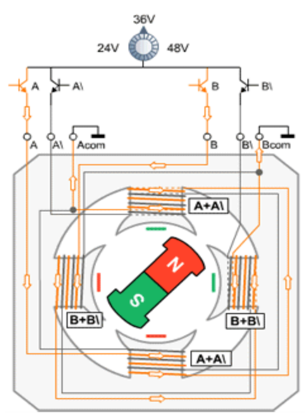
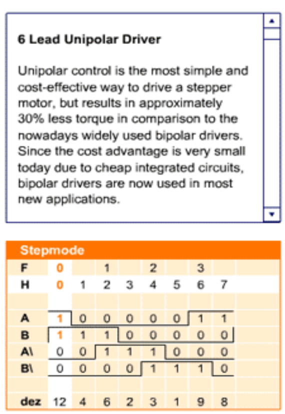


Figure 29: Stepper Motor Control using ATMEGA-16 Microcontrolle

5. EQUATIONS AND CODINGS

Half step sequence: Here motor's step angle reduces to half the angle than in full mode. So the angular resolution is also increased i.e., it becomes double the angular resolution than in full mode. Also in half mode sequence the no. of steps gets double as that of full mode. Half mode is usually preferred over full mode. The patterns of energizing the coils are:





5.1 Step angle calculation
Step Angle, Φ = 360/ No. of steps

FULL SEQUENCE:
Step Angle, Φ = 360/4 = 90 degree

HALF SEQUENCE:
Step Angle, Φ = 360/8 = 45 degree

Direction for rotation of stepper motor
CLOCKWISE ROTATION:

For Clockwise Rotation, step sequence should be:

i. 0-1-2-3 (In case of full sequence)
ii. 0-1-2-3-4-5-6-7(In case of half sequence)

ANTICLOCKWISE ROTATION:
For Anti-Clockwise Rotation, step Sequence should be:

i. 3-2-1-0 (In case of full sequence)
ii. 7-6-5-4-3-2-1-0 (In case of half sequence)

Stepper Motor Programming:
Here the programming for stepper motor is of half step sequence, i.e., at 45^o angle the solar array will be rotated at certain delay of time (according to the time given in the programming). The stepper motor is a unipolar stepper motor having 5V, six terminals and 1.8^o per step. The crystal frequency of the microcontroller is of 8MHz. The software used for the execution of the programming is **WINAVR**. Using **progisp** software, the hex file is being burned. The programming of half step sequence of stepper motor is given below.

5.2 PROGRAMMING:

```
#include<avr/io.h>
#include<util/delay.h>
int main(void)
{
DDRA=0xFF;          // set portA as out put
while(1)            // run forever
{
PORTA=0b00001100;
_delay_ms(1000);  ---------------- and so on
```

6. TESTING OF THE PROPOSED SYSTEM

INVERTER OUTPUT:

IC- 555 timer use as a bistable multivibrator terminal 3 gives output of a square wave with 50% duty cycle. Q2 converting upper half cycle into alternating current and Q3 converting lower half cycle into alternating current, Q2 and Q3 are MOSFETs. Q1 used as a switching element (BC 549). So transformer primary input is having 12 volt A.C and in the secondary side ideal output is 220 volt 50HZ. But after completing the circuit formation the output getting is approximately 200volt, 50Hz.

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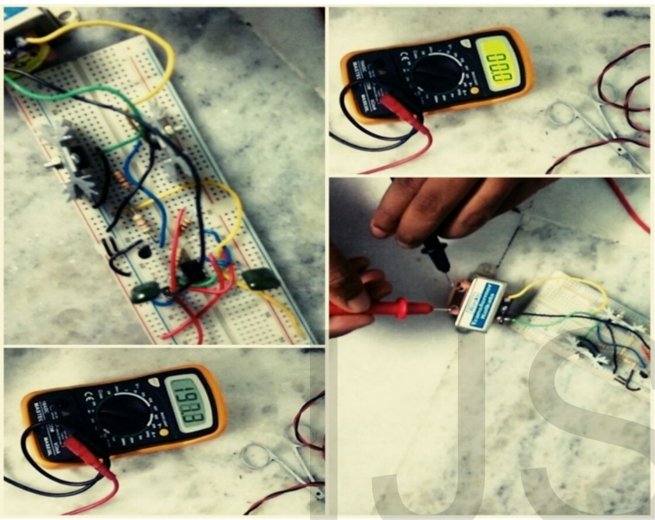
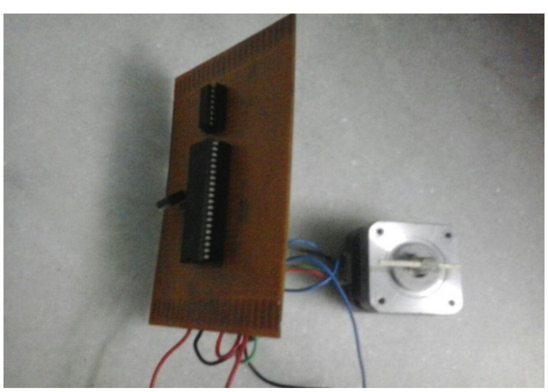
Figure 30: Square Waveform to Sine Waveform

MICROCONTROLLER BASED STEPPER MOTOR OUTPUT:

We got an angle of 45^{o} (approx.) rotation in every step sequence as per our logic given to the microcontroller ATMEGA16 interfacing with 5V, 1.8^{o} per step stepper motor.
The motor can bear up to 2kg of mechanical loading.





7. Conclusion

All energy sources have an impact on the environment. Concerns about the greenhouse effect and global warming, air pollution, and energy security have led to increasing interest and more development in renewable energy sources such as solar, wind, geothermal, etc.
But we'll need to continue to use fossil fuels and nuclear energy until new, cleaner technologies can replace them.
The future is ours, but we need energy to get there.
This project idea is taken from solar power system and we trying to make solar generation model for study purpose. This project gives a view of solar generation and the inverter which we have designed is very simple and cheap.

8. References

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