CHAPTER 1- LITERATURE SURVEY

1.1. INTRODUCTION

The great thing about solar energy systems is that they offer people the chance to be self sufficient. A one off investment in solar technology means that the can utilize the energy that is produced by the sun; forever! The great thing is that for they can instantly convert the energy from the sun and use the electricity that has been created to provide free power for their home.

The fact of the matter is; solar energy is being wasted every single day. We use fossil fuels like they are never going to run out; but they eventually will. Instead, the sun is there, producing energy all day every day, but we as consumers are not capitalizing on this fact. Instead we pay over inflated prices to electricity suppliers for our utilities.

Besides the money saving aspect, the advantages solar power are obviously that they don’t harm the environment. You can do your part in saving the environment and save a lot of money if you make high efficiency solar cells at home and use the to run your house on sun power with solar energy.

Nowadays there are all kinds of grand schemes and income opportunities for individuals and businesses that are looking to use or create solar energy using solar energy systems. So it seems that now is the right time to get involved and get solar energy systems of our own!
1.2. HISTORY

Solar energy has been used by humans for thousands of years. For example, ancient cultures used energy from the sun to keep warm by starting fires with it. They also kept their homes warm through passive solar energy designs. Buildings were designed so that walls and floors collected solar heat during the day that was released at night to keep them warm. If you have ever stood in the sun to get warm then you too have utilized solar thermal energy.

The discovery of photovoltaic’s happened in 1839 when the French physicist Edmond Becquerel first showed photovoltaic activity. Edmond had found that electrical current in certain materials could be increased when exposed to light. Sixty-Six years later, in 1905, we gained an understanding of Edmonds' work when the famous physicist Albert Einstein clearly described the photoelectric effect, the principle on which photovoltaics are based. In 1921 Einstein received the Nobel Prize for his theories on the photoelectric effect.

Solar cells of practical use have been available since the mid 1950’s when AT&T Labs first developed 6% efficient silicon solar cells. By 1960 Hoffman Electronics increased commercial solar cell efficiencies to as much as 14%.

The energy crisis and oil embargos of the 1970’s made many nations aware of their dependency on controlled non-renewable energy sources and this fueled exploration of alternative energy sources. This included further research into renewable sources such as solar power, wind power and geothermal power.

An economic breakthrough occurred in the 1970’s when Dr. Elliot Berman was able to design a less expensive solar cell bringing the price down from $100 per watt to $20 per watt. This huge cost savings opened up a large
number of applications that were not considered before because of high costs. These applications included railroads, lighthouses, off-shore oil rigs, buoys, and remote homes. For some countries and many applications, solar energy is now considered a primary energy source, not an alternative.

1.3. OUR PROJECT

Solar energy is the future when it comes to energy requirement of humans. About 47 per cent of the energy that the sun releases to the earth actually reaches the ground. About a third is reflected directly back into space by the atmosphere. The time in which solar energy is available, is also the time we least need it - daytime. Because the sun's energy cannot be stored for use another time, we need to convert the sun's energy into an energy that can be stored. The solar panels generate low grade heat, that is, they generate low temperatures for the amount of heat needed in a day. The energy can be harnessed with help of Solar Panels. However this energy is highly inefficient in terms of the energy density (power/area). Therefore we need a method to ensure that the energy being cultivated is harnessed efficiently. The Sun is a star, around which Earth keeps rotating and revolving. Due to its rotation, relatively the Sun moves 360 degrees around the earth with respect to Earth. Therefore there comes the requirement of facing the Solar Energy harnessing equipment continuously to the Sun. The project aims at achieving this by automatically adjusting the alignment of the Solar Panel with respect to the Sun. Trackers compile of solar panels, light detecting materials, motors, connecting wires and microcontrollers. We also need an algorithm to govern the working of the tracker.
COMPONENTS REQUIRED FOR TRACKING

The Automatic Solar tracking System developed by our group includes mainly three types of components.

a) Mechanical
b) Electrical
c) Electro-Mechanical

A. MECHANICAL COMPONENTS

The tracking system to be projected by our group will include a few basic mechanical components to ensure smooth and frictionless movement of the solar panel.

The various mechanical components include

a) Pulleys: Two normal pulleys with different diameters are used. One is at least 4-5 times bigger than the smaller pulley.
b) Belt: Belt is used to rotate bigger pulley with the help of smaller pulley.
c) Bearings: Bearings are used to provide a friction free rotation of the metal rod.
d) Wheels: Wheels are used to rotate the entire assembly in a circular path.

B. ELECTRICAL COMPONENTS

The tracking system requires a fair amount of signal conditioning to ensure that the motors get correct electric input for facilitating the Solar Panel with the right direction and right amount of motion.

The various electrical components include

a) Operational Amplifiers
b) Relays
c) Light Dependent Resistors
d) DC Voltage supply
c) **555 IC – Timer circuit**

d) **Resistors**

### C. ELECTRO-MECHANICAL COMPONENTS

The Electro-Mechanical components only include the motors used to change the position of the solar panel.

The motors we use are 12 V DC motors.

### 1.4. PROJECT LIMITATIONS

Availability is a major issue related to solar power. Suppose you are in a location which receives light sunlight, then it gets difficult to take its advantage. Though it is free and easy to harness, nevertheless its availability is not guaranteed in every region across the globe.

Weather and climatic changes is also one drawback. If there are dark and dense clouds, they definitely will hinder the sunrays to reach their point. Ultimately dim light will reach and the power supply of your household will be affected.

Nevertheless Solar energy has some drawbacks; yet it should be utilized at maximum in order to lessen the burden from natural resources and to get fully prepared for the time when we no longer will be having the rapidly finishing natural resources.
CHAPTER 2-PROCESS INFORMATION

2.1 OPERATIONAL AMPLIFIER SUMMARY

The circuit symbol for an op-amp is shown below,

Where:

- \( V_+ \): non-inverting input
- \( V_- \): inverting input
- \( V_{OUT} \): output
- \( V_{s+} \): positive power supply
- \( V_{s-} \): negative power supply

The power supply pins (\( V_{s+} \) and \( V_{s-} \)) can be labeled in different ways. Despite different labeling, the function remains the same to provide additional power for amplification of the signal. Often these pins are left out of the diagram for clarity, and the power configuration is described or assumed from the circuit.

![Op-Amp Circuit Symbol]

Fig 2.1.1

The amplifier's differential inputs consist of a \( V_+ \) input and a \( V_- \) input, and ideally the op-amp amplifies only the difference in voltage between the two, which is called the differential input voltage. The output voltage of the op-amp is given by the equation,

\[
V_{out} = (V_+ - V_-) A_{OL}
\]

Where \( V_+ \) is the voltage at the non-inverting terminal, \( V_- \) is the voltage at the inverting terminal and \( A_{OL} \) is the open-loop gain of the amplifier (the term "open-loop" refers to the absence of a feedback loop from the output to the input).
The magnitude of $A_{OL}$ is typically very large for integrated circuit op-amps and therefore even a quite small difference between $V_+$ and $V_-$ drives the amplifier output nearly to the supply voltage. This is called saturation of the amplifier.

2.2. OPERATIONAL AMPLIFIER 741

![741 Op. Amp. diagram]

Fig.2.2.1

An operational amplifier ("op-amp") is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output. An op-amp produces an output voltage that is typically hundreds of thousands times larger than the voltage difference between its input terminals.

The op-amp is one type of differential amplifier. The amplifier's differential inputs consist of a $V_+$ input and a $V_-$ input, and ideally the op-amp amplifies only the difference in voltage between the two, which is called the differential input voltage.
The **op-amp** is being used as a **voltage comparator**.

A ‘comparator’ is a circuit that compares two input voltages. One voltage is called the reference voltage (**Vref**) and the other is called the input voltage (**Vin**).

When **Vin** rises above or falls below **Vref** the output changes polarity (+ve becomes -ve).

Positive is sometimes called **HIGH**.
Negative is sometimes called **LOW**.

**APPLICATIONS OF OP-AMP:**

- Voltage follower
- Inverting amplifier
- Non-inverting amplifier
- Nonlinear (algorithmic) amplifier
- Differential amplifier
- Summing amplifier
- Differentiator
- Integrator
2. 3 LIGHT-DEPENDENT RESISTOR

As its name implies, the Light Dependent Resistor (LDR) is made from a piece of exposed semiconductor material such as cadmium sulphide that changes its electrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when light falls upon it by creating hole-electron pairs in the material. The net effect is an improvement in its conductivity with a decrease in resistance for an increase in illumination.

When the light level is low the resistance of the LDR is high. This prevents current from flowing. However, when light shines onto the LDR its resistance falls and current starts flowing. An LDR has a zigzag cadmium sulphide track. It is a bilateral device, i.e., conducts in both directions in same fashion.

Fig.2.3.1
2.4 RELAYS

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. Relays allow one circuit to switch a second circuit which can be completely separate from the first.

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open.
The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

**NORMALLY OPEN AND NORMALLY CLOSED RELAYS**

![Diagram of relay configurations](image)

*Fig.2.4.2*

*Fig.2.4.3*
Relays are either normally open or normally closed. Normally open relays have a switch that remains open until energized (ON) while normally closed relays are closed until energized. Relays are always shown in the de-energized position (no current flowing through the circuit-OFF).
2.5 DC MOTORS

A DC motor is an electric motor that runs on direct current (DC) electricity. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles.

There are 2 types if DC motors.

1. Brushed DC electric motor
2. Brushless DC electric motor
1. BRUSHED DC ELECTRIC MOTOR

The brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets.

Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the brushes and springs which carry the electric current, as well as cleaning or replacing the commutator.

2. BRUSHLESS DC ELECTRIC MOTOR

Brushless DC motors use a rotating permanent magnet or soft magnetic core in the rotor, and stationary electrical magnets on the motor housing. A motor controller converts DC to AC. This design is simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.
2.5.1 CONNECTION TYPES

1. SERIES CONNECTION

A series DC motor connects the armature and field windings in series with a common D.C. power source. This motor has poor speed regulation since its speed varies approximately inversely to load. However, a series DC motor has very high starting torque and is commonly used for starting high inertia loads, such as trains, elevators or hoists. With no mechanical load on the series motor, the current is low, the magnetic field produced by the field winding is weak, and so the armature must turn faster to produce sufficient counter-EMF to balance the supply voltage (and internal voltage drops). For some types of motor, the speed may be higher than can be safely sustained by the motor. In a no-load condition, the motor may increase its speed until the motor mechanically destroys itself. This is called a runaway condition. The speed/torque characteristic is also useful in applications such as dragline excavators, where the digging tool moves rapidly when unloaded but slowly when carrying a heavy load.

2. SHUNT CONNECTION

A shunt DC motor connects the armature and field windings in parallel or shunt with a common D.C. power source. This type of motor has good speed regulation even as the load varies, but does not have as high of starting torque as a series DC motor. It is typically used for industrial, adjustable speed applications, such as machine tools, winding/unwinding machines.
3. COMPOUND CONNECTION

A compound DC motor connects the armature and fields windings in a shunt and a series combination to give it characteristics of both a shunt and a series DC motor. This motor is used when both a high starting torque and good speed regulation is needed. The motor can be connected in two arrangements: cumulatively or differentially. Cumulative compound motors connect the series field to aid the shunt field, which provides higher starting torque but less speed regulation. Differential compound DC motors have good speed regulation and are typically operated at constant speed. They are commonly used in elevators, air compressors, conveyors and punch presses.
2.6 CAPACITOR

Fig.2.6.1

A capacitor (originally known as condenser) is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film.

A capacitor consists of two conductors separated by a non-conductive region. The non-conductive region is called the dielectric. In simpler terms, the dielectric is just an electrical insulator. Examples of dielectric media are glass, air, paper, vacuum, and even a semiconductor depletion region chemically identical to the conductors. A capacitor is assumed to be self-contained and isolated, with no net electric charge and no influence from any external electric field. The conductors thus hold equal and opposite charges on their facing surfaces and the dielectric develops an electric field. In SI units, a
capacitance of one farad means that one coulomb of charge on each conductor causes a voltage of one volt across the device.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks, for smoothing the output of power supplies, in the resonant circuits that tune radios to particular frequencies, in electric power transmission systems for stabilizing voltage and power flow, and for many other purposes.

Fig.2.6.2
2.7 RESISTORS

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals. Thus, the ratio of the voltage applied across a resistor's terminals to the intensity of current through the circuit is called resistance. This relation is represented by Ohm's law:

\[ I = \frac{V}{R} \]

where \( I \) is the current through the conductor in units of amperes, \( V \) is the potential difference measured across the conductor in units of volts, and \( R \) is the resistance of the conductor in units of ohm.
Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits.

Resistors have been used for current biasing and voltage regulating. The electrical functionality of a resistor is specified by its resistance: common commercial resistors are manufactured over a range of more than nine orders of magnitude. When specifying that resistance in an electronic design, the required precision of the resistance may require attention to the manufacturing tolerance of the chosen resistor, according to its specific application.
### Standard EIA Color Code Table 4 Band: ±2%, ±5%, and ±10%

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<td></td>
<td></td>
<td>10^{-2}</td>
<td>±10%</td>
</tr>
</tbody>
</table>
2.8. 555 Timer: Astable mode

Fig.2.8.1

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>Ground, low level (0 V)</td>
</tr>
<tr>
<td>2</td>
<td>TRIG</td>
<td>OUT rises, and interval starts, when this input falls below 1/3 $V_{cc}$</td>
</tr>
<tr>
<td>3</td>
<td>OUT</td>
<td>This output is driven to $+V_{cc}$ or GND.</td>
</tr>
<tr>
<td>4</td>
<td>RESET</td>
<td>A timing interval may be interrupted by driving this input to GND.</td>
</tr>
<tr>
<td>5</td>
<td>CTRL</td>
<td>&quot;Control&quot; access to the internal voltage divider (by default, 2/3 $V_{cc}$).</td>
</tr>
<tr>
<td>6</td>
<td>THR</td>
<td>The interval ends when the voltage at THR is greater than at CTRL.</td>
</tr>
<tr>
<td>7</td>
<td>DIS</td>
<td>Open collector output; may discharge a capacitor between intervals.</td>
</tr>
<tr>
<td>8</td>
<td>$V_+, V_{cc}$</td>
<td>Positive supply voltage is usually between 3 and 15 V.</td>
</tr>
</tbody>
</table>
1) In astable mode there is no stable state. Output jumps between Vcc and Ground.

2) Output is a square wave with a mark period and a space period.

3) Frequency is set by $R_1$, $R_2$ and $C$

$$T_{mark} = 0.7(R_1 + R_2)C$$
$$T_{space} = 0.7R_2C$$

$$F = \frac{1.44}{(R_1 + 2R_2)C}$$

4) Uses - flashing light, tone, pulse width modulation.
2.9. SOLAR PANEL

A solar panel (also solar module, photovoltaic module or photovoltaic panel) 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 applications. Each panel is rated by its DC output power under standard test conditions, and typically ranges from 100 to 450 watts.

Fig.2.9.1

Solar panels use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The structural (load carrying) member of a module can either be the top layer or the back layer. The majority of modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. The conducting wires that take the
current off the panels may contain silver, copper or other non-magnetic conductive transition metals.

When solar radiation falls on solar panels, it is converted directly into dc current. Main advantages associated with solar panels are that they have no moving parts, require little maintenance, and work quite well with beam or diffuse solar radiation.
2.10 BATTERY

An electrical battery is one or more electrochemical cells that convert stored chemical energy into electrical energy. A battery's capacity is the amount of electric charge it can store. The more electrolyte and electrode material there is in the cell the greater the capacity of the cell.

Because of the chemical reactions within the cells, the capacity of a battery depends on the discharge conditions such as the magnitude of the current (which may vary with time), the allowable terminal voltage of the battery, temperature, and other factors. The available capacity of a battery depends upon the rate at which it is discharged. If a battery is discharged at a relatively high rate, the available capacity will be lower than expected.
FEATURES:
Key Specifications/Special Features:

* Sealed lead-acid battery
* Nominal voltage: 12V
* Rated capacity: 7Ah/7.5ah/20hr
* Dimensions:
  o Height over terminal (H): 100mm (3.93 inches)
  o Container height (h): 96mm (3.78 inches)
  o Length (L): 151mm (5.94 inches)
  o Width (W): 65mm (2.56 inches)
* Weight: approx 2.51kg
* Internal resistance: approx 25m ohm
* Max charging current: 2.10A
* Max discharged current: 100/120 A (5 sec)
* Provides hundreds of cycles
* Safety valve design
* Usable in any position
* Long service life
* CASIL batteries are 100% two-cycle.
2.11PULLEY SYSTEM

To cover circular motion we have rotated the entire assembly in circular direction with the help of the wheels attached below. And to cover east to west direction we have used pulley and belt arrangement. Here the smaller pulley is driven by the motor depending upon the respective photo sensors effect. This smaller pulley again drives the bigger pulley with the help of a tightly placed belt over the two pulleys. This enables the motion in the east to west direction.

Above diagram depicts the flow of the working. When the assembly is turned on by microcontroller the circuit checks the input from the photo sensors. This is then given for signal conditioning. Signal conditioning circuit drive motors according to respective sensors signal. Then a circuit checks the status of the photo sensors and drives the motor till solar panel faces the sun directly. As solar panel faces the sun microcontroller switch the circuit off for 14 min to save energy.
The above circuit is used to rotate the solar panel in the direction of the sun depending upon the respective sensors signal. One circuit rotates the solar panel in east to west direction and other circuit is used to rotate solar panel in circular direction. The above circuit is very basic circuit consisting of 741 op-amps, relays, LDRs DC motors.
2.12.1 WORKING OF CIRCUIT:

For the motion along each axis a pair of LDR is used. These LDRs are separated from each other by a small partition. This helps to trace direction of sun more accurately. Resistance of LDRs changes depending upon the sunlight incident upon it. Intensity and resistance are in inverse relation in LDR. i.e. as the intensity increases the resistance decreases and vice versa. This change in the resistance of LDRs is converted into equivalent potential by a voltage divider connection. This voltage is then given to the 741 op-amps. A potentiometer is connected to change the resistance at any time in future if needed. Op-amp either gives output as ‘0 V’ or ‘12V’ depending upon the input coming to it. If the output of the op-amp is ‘12V’ then the potential difference across the relay will be zero and circuit is not completed. If the output is ‘0 V’ then relay will be switched and ‘12V’ goes to the two relays ahead. These two relays provide necessary ‘+ ve’ and ‘-ve’ supply to the motor and completes the circuit for motor. Hence the direction of rotation of the motor will be ultimately governed by the LDRs.

2.12.2 ROTATION IN EAST TO WEST DIRECTION:

For rotation of solar panel in east to west direction the sensors are mounted just besides the solar panel. When the sunlight falls on it, sensors starts changing their output accordingly and the DC motor starts rotating the panel towards the sun in east to west direction.
2.12.3 ROTATION IN CIRCULAR DIRECTION:
To cover the sideways motion of the sun during the year we have used this technique. In this we rotate the entire assembly in circular path to track the sun. The circuit remains the same as shown above just the sensors position change. Sensors for this is mounted in front of the solar panel. They give the appropriate signal according to sun’s position and make the entire assembly to move in circular path with the help of the four DC motor mounted at bottom.

2.13 555 TIMER

![555 Timer Circuit Diagram]

R2=mega ohm, R1=6.6 mega ohms

C=100micro Faraday
The above shown diagram is circuit diagram of timer circuit using 555. Using this circuit we are generating a square wave of 9 min ON and 1 min OFF. It is then given to a relay which will either give the entire circuit supply or close it. If the square wave is giving high output i.e. ON then the circuit will not be supplied any power i.e. it will be OFF. If the output of timer is low i.e. OFF then the relay will change circuit entire circuit and the circuit supply contact and will ON.

Hence the entire circuit will be ON for 1 min and OFF for 9 min.
2.14 Project Idea

A solar cell generates DC electricity from light, which in turn can be used in many applications such as: charging batteries, powering equipment, etc. They produce currents as long as light shines, and this produced currents can be stored in a battery and can be used later on in night. The figure below shows the schematic representation of above sentences.

This solar tracking system will track maximum intensity of light. When there is decrease in intensity of light, this system automatically changes its direction to get maximum intensity of light.

Here we are using photo sensors to sense the direction of maximum intensity of light. The difference between the outputs of the sensors is given to the 555 timer unit. Here we are using the 555 timer for tracking and generating power.
from sunlight. It will process the input voltage from the comparison circuit and control the direction in which the motor has to be rotated so that it will receive maximum intensity of light from the sun. The power generated from this process is then stored battery and is made to charge an emergency light and is made to glow during night.
2.15 Algorithm

Fig. 2.15.1
Above diagram shows the basic flow of the entire system. When the system is turned on the circuit starts checking values of sensors. These values are then given to the signal conditioning circuit. Signal conditioning circuit compares the output of both the sensors. If those values are not same then the motor rotates in the direction where the difference between values of both the sensor becomes less. This goes on till the difference becomes almost zero. When the difference become zero the motors stops rotating and the panel becomes stationary. This logic is independently applied to both the axis but their working algorithm remains the same.
3.1 APPLICATION

Solar power deals with the use of solar radiation for practical purposes. It has been employed in order to decrease the carbon footprints from our environment. It is the basic motor of all forms of energy generation methods. It is free and clean to use. This form of energy is available in abundance in our environment. The fossil fuels are also mere frozen solar power. Solar energy has remained a necessary ingredient for decades now. It's demand for usage still prevails.

As the technology has advanced, we now have started making use of electric vehicles too. Such vehicles have started becoming readily available and are operated using battery technology as well as solar energy. Their costs are now dropping and such vehicles are becoming readily available to the masses. Electric vehicles have a wonderful future for sure as they do not pollute the environment. They are also cheap in their usage.

ADVANTAGES:

- Solar Energy is a renewable form of energy and tends to give us large amount of energy and light. Oil, on the other hand is not renewable and also degrades the environment.
- Solar cells are very silent in their working and they are quite efficient too,
- Solar energy equipments do not emit any harmful gases or radiations. They are highly eco-friendly.
- Solar cells require very less maintenance and they have a long life too.
- Though, the initial set up of the solar panels is expensive, later on they turn out to be highly cost effective,
3.2. CONCLUSION

Our automatic solar tracking system will not only provide means to solar energy, but will also do this in very efficient manner. With some help of signal conditioning the source from the solar panel can be further used to charge various electrical devices.
Fig 3.1.1
BIBLIOGRAPHY


