Sudan University of Science and Technology

College of Engineering

Electrical Engineering

Auto Irrigation System Using Solar Energy

نظام ري آلي بإستخدام الطاقة الشمسية

A Project Submitted In Partial Fulfillment for the Requirements of the Degree of B.SC. (Honor) In Electrical engineering

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October 2017

بسم الله الرحمن الرحيم

" وَهُوَ الَّذِي أَنزَلَ مِنَ السَّمَآءِ مَآءً فَأَخْرَجْنَا بِهِ نَبَاتَ كُلِّ شَيْءٍ فَأَخْرَجْنَا مِنْهُ خَضِراً نُّخْرِجُ مِنْهُ حَبّاً مُّتَرَاكِباً وَمِنَ النَّخْلِ مِن طَلْعِهَا قِنْوانٌ دَانِيَةٌ وَجَنَّاتٍ مِّنْ أَعْنَابٍ وَالزَّيْتُونَ وَالرُّمَّانَ مُشْتَبِهاً وَغَيْرَ مُتَشَابِهٍ انْظُرُواْ إِلِى ثَمَرِهِ إِذَآ أَثْمَرَ وَيَنْعِهِ إِنَّ فِي ذَلِكُمْ لآيَاتٍ لِّقَوْمٍ يُؤْمِنُونَ"

(سورة الانعام:الاية 99)

صدق الله العظيم

DEDICATION

As well as everything that we do, we would be honor to dedicate this work to our parents for their emotional and financial support, our brothers, our sisters and our friends especially our friend **Mohammed Gamal,** whose has been constant source of inspiration for us. They have given us the drive and discipline to tackle any task with enthusiasm and determination. Without their love and support this project would not have been made possible.

ACKNOWLEDGEMENT

First and above all, we praise God, the almighty for providing us this opportunity, and granting us the capability to proceed successfully. Grateful for this opportunity, we would like to give our sincere thanks to our supervisor**, Ust.Gaffar Babiker Osman** for his valuable guidance, continues encouragement, suggestions, constructive ideas and advice in assisting us to complete this work.

ABSTRACT

Automatic irrigation system powered by solar energy is a system designed to control the irrigation operation and use the solar energy as a source of power. The main goal of the project is to design a system that irrigate seeds without human contribution, also to provide the system with power that needed by solar panels. The challenge is to adjust the perfect humidity to the plants. The result of this thesis is a system use soil moisture sensor to sense the humidity of the soil which will control the pump. The design has been developed successfully. The running cost of the irrigation has been reduced and the physical effort in irrigation is saved. There were not many unexpected problem during the implementation of the system. However, there is still possibility for further improvement such as, adding machines to pesticides the seeds.

المستخلص

يُعنى المشروع بدراسة وتصميم نظام تحكم لعملية الري في المزارع بحيث يكون مصدر الطاقة هو الطاقة الشمسية.إن الهدف الاساسي من المشروع هو تصميم نظام يروي المحاصيل من دون تدخل الايادي البشرية، وايضا تزويد النظام بالطاقه الشمسية وتحقيق مبداء الاكتفاء الذاتي.

يتمثل التحدي في كيفية ضبط رطوبة التربة التى تحوي المحاصيل، نتيجة لذلك تم استخدام محساس رطوبة تربة حتى يقراء رطوبة التربة ويتحكم في تشغيل وايقاف طرمبة الماء التي تروي المحاصيل.

لم تكن هنالك مشاكل غير متوقعة، ولكن هنالك إمكانية لتحسين النظام باضافة ماكينات تعمل على رش المبيدات الحشرية على المحاصيل لتحسين جودتها.

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LIST OF ABBREVIATIONS

AM	Air mass
AMO	Air mass is zero
AM1	Air mass of one
PV	Photovoltaic
DC	Direct current
AC	Alternate current
BOS	Balance of system

LIST OF SYMBOLS

E	Photon energy, J
H	Planck's constant, 6.62607004*10^{-34} m^2/kg
V	Frequency of the light, Hz
E_{ph}	Photon energy, J
E_g	Bandgap, J
E_c	Conduction bandgap, J
E_r	Valence bandgap, J
E_i	Initial energy level, J
E_f	Higher energy level, J

CHAPTER ONE

INTRODUCTION

1.1 General Concepts

Since the beginning of the world, seeds are very important part of human life. They are the main source of food and consider as important contributor in pharmacy and industry fields.

To grow a perfect seed all the condition that affect on it must be perfect and that may cause some problems because the farmers are human being and could commit an error in irrigation.

Irrigation is the main part of the agriculture operation and the real challenge is to reduce the cost of this operation as possible to get a healthy crop. Nowadays machines and control systems slowly taking a part of human jobs and do it in better way. Irrigation one of the fields that control systems could apply on it.

1.2 Problem Statement

Irrigation operation needs expert farmer to adjust the perfect humidity for the seeds. Also it cost a lot of money to hire farmers and to pay for the electricity that used to operate the pumps which is used to deliver the water to the seeds.

1.3 Objectives

The main objectives of the study are to:

- Reduce the running cost of irrigation systems.
- Build an accurate system to adjust the perfect humidity for the seeds.
- Save the physical effort and time in irrigation operation.
- Implement a system that provides enough energy to the farm.
- Improve the quality of the seeds.

1.4 Methodology

- Study irrigation systems.
- Study electrical pumps.
- Study principles of solar energy.
- Draw the block diagram.
- Draw the schematic diagram.
- Build Arduino program to control the system.
- Design the automatic irrigation system.

1.5 Project Layout

The project consist of an abstract and five chapters: chapter one gives an introduction about the principles of the project, in addition its reasons, motivation and objectives. Chapter two deals with the irrigation systems, consists of types of irrigation, water resources, pumps and their types. Chapter three illustrates the solar energy which contains, the nature of light, photovoltaic and its effect, types of photovoltaic cells and solar arrays. Chapter four show the component of the project and how the systems operate. Chapter five represent the conclusion and the recommendations.

CHAPTER TWO

IRRIGATION SYSTEMS

2.1 Introduction

Irrigation is the application that controlled amounts of water to plant at needed intervals. Irrigation helps grow agricultural crops, maintain landscape, and revegetate disturbed soils in dry areas and during periods of inadequate rainfall. Irrigation also has other uses in crop production, including frost protection, suppressing weed growth in grain fields and preventing soil consolidation. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed or dry land farming[1].

Irrigation systems are also used for cooling livestock, dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the removal of surface and sub-surface water from a given area.

Irrigation has been a central feature of agriculture for over 5,000 years and is the product of many cultures. Historically, it was the basis for economies and societies across the globe, from Asia to the South-western United States.

Irrigation has important roles in agricultural fields mentioned below:

- Irrigation maintains moisture in the soil. Moisture is necessary for the germination of seeds. Seeds do not grow in dry soil. That is why irrigation is done before tilling.

- Irrigation is essential for the growth of the roots of the crop plants. Roots of the plants do not grow well in dry soil.

- Irrigation is necessary for the absorption of mineral nutrients by the plants from the soil. Thus, irrigation is essential for the general growth of the plants.
- Water supplies two essential elements hydrogen and oxygen to the crop.

2.2 Types of Irrigation Systems

Irrigation has many types such as: surface irrigation, sub-irrigation, sprinkler irrigation, manual irrigation, drip irrigation and center-pivot irrigation.

2.2.1 Surface irrigation

Surface irrigation is defined as the group of application techniques where water is applied and distributed over the soil surface by gravity as shown in figure (2.1). It is by far the most common form of irrigation throughout the world and has been practiced in many areas virtually unchanged for thousands of years.

Surface irrigation is often referred to as flood irrigation, implying that the water distribution is uncontrolled and therefore, inherently inefficient. In reality, some of the irrigation practices grouped under this name involve a significant degree of management (for example surge irrigation). Surface irrigation comes in three major types; level basin, furrow and border strip.

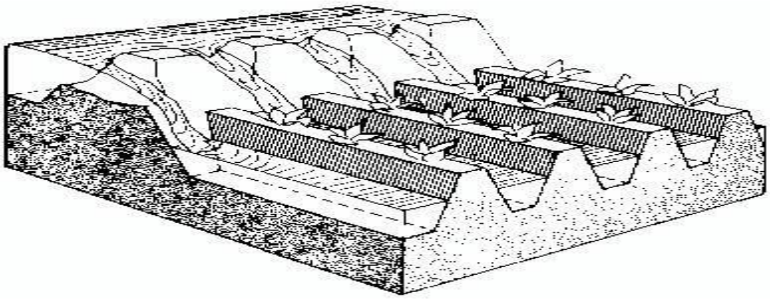

Figure 2.1: Surface Irrigation

2.2.2 Drip irrigation

Drip irrigation is a type of micro-irrigation that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants as shown in figure (2.2), either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation. Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters. Depending on how well designed, installed, maintained, and operated it is, a drip irrigation system can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation[2].

Figure 2.2: Drip Irrigation

2.2.3 Sprinkler irrigation

An irrigation sprinkler is a device used to irrigate agricultural crops, lawns, landscapes, golf courses, and other areas. They are also used for cooling and for the control of airborne dust. Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall as shown in figure (2.3). Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump, valves, distribution pipes, and sprinklers are generally designed to apply water as uniformly as possible[3].

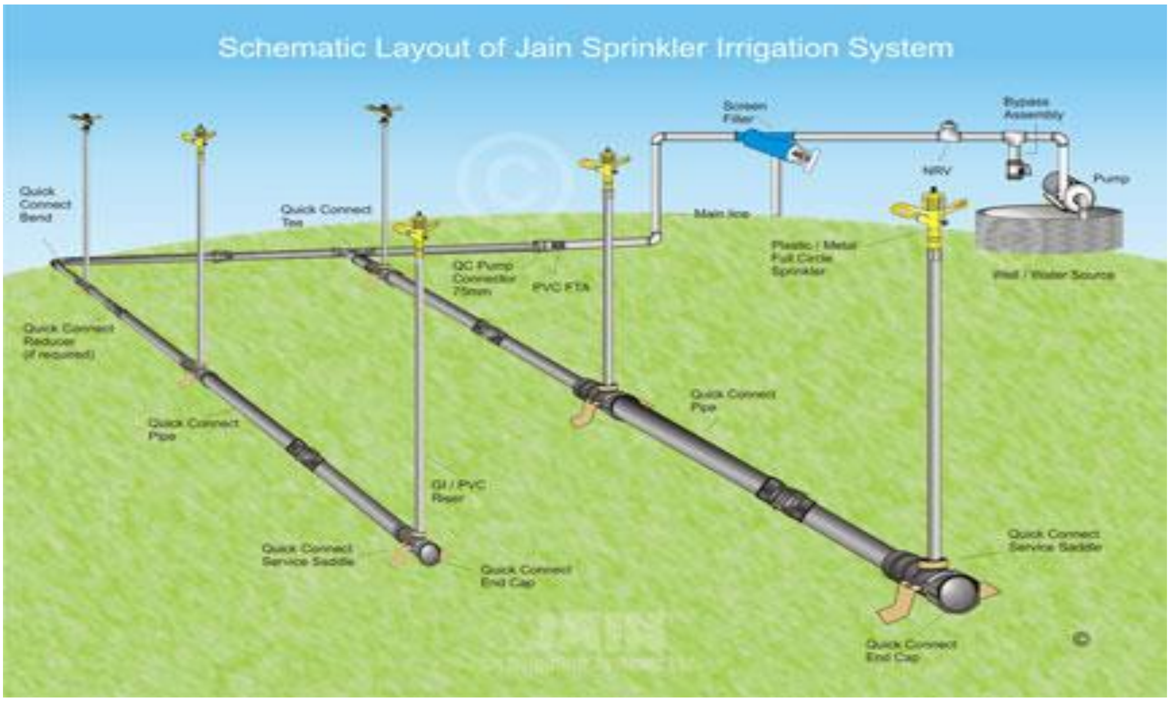

Figure 2.3: Sprinkler Irrigation

2.2.4 Center-pivot irrigation

Center-pivot irrigation (sometimes called central pivot irrigation), also called waterwheel and circle irrigation, is a method of crop irrigation in which equipment rotates a round a pivot and crops are watered with sprinklers as shown in figure (2.4). A circular area centered on the pivot is irrigated, often creating a circular pattern in crops when viewed from above (sometimes referred to as crop circles). Most center pivots were initially water-powered, and today most are propelled by electric motors.

Figure 2.4: Center-pivot Irrigation

2.2.5 Sub-irrigation

Sub-irrigation as shown in figure (2.5) is used in growing field crops such as tomatoes, peppers, and sugar cane in areas with high water tables such as Florida and in commercial greenhouse operations.

Three basic types of sub-irrigation system are in general use for potted plants in greenhouses: ebb-and-flow (bench-mounted enclosures holding pots are filled and then drained), trough (water is flowed through bench-mounted, slightly sloping enclosures containing pots), and flooded floor (special sloped concrete flooring is flooded and drained).

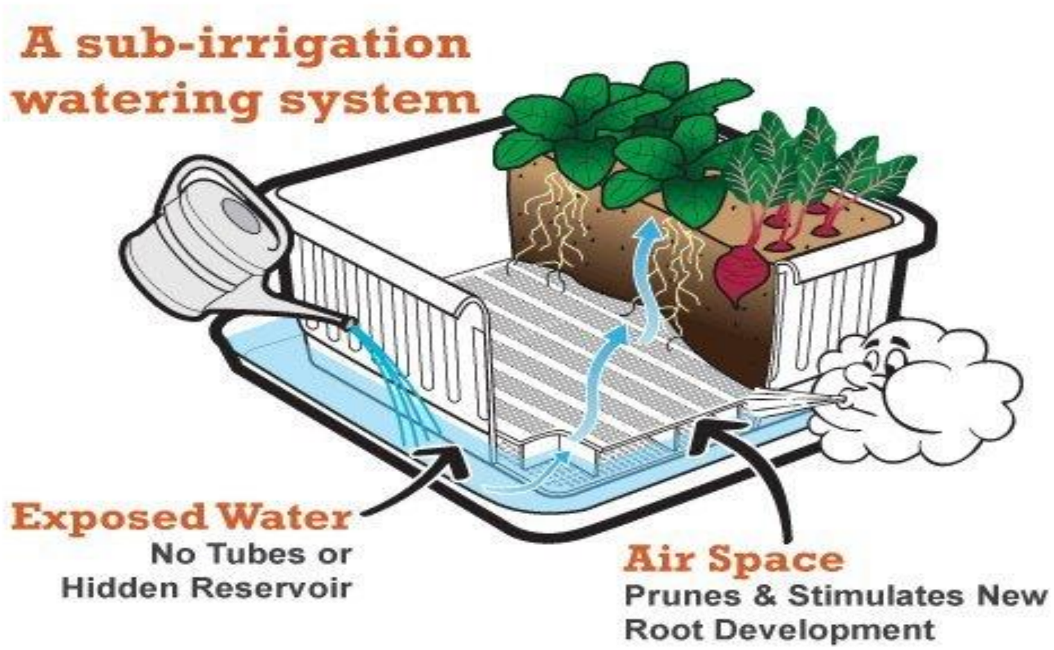

Figure 2.5: Sub-irrigation

Greenhouse sub-irrigation has been growing in popularity since the 1990s. Advantages are water and nutrient conservation, and labor-saving. The outfitting cost is relatively high. Potential problems, such as the possibility of increased presence of disease in recycle water, have only begun to be investigated.

One of the disadvantages of sub-irrigated closed systems, such like Earth Boxes and sub-irrigated planters, is that soluble salts cannot be flushed into the lower soil profile and build up over time.

2.2.6 Manual irrigation

Manual irrigation systems -as shown in figure (2.6)- are easy to handle, require no technical equipment and are therefore generally cheap (in contrast to high-tech systems such as sprinkler irrigation or subsurface drip irrigation). But they need high labor inputs. A common and very simple technique for manual irrigation is for instance the use of watering cans as it can be found in urban agriculture around large cities in some African countries. A more sophisticated and very water-efficient type of manual irrigation system is small-scale drip irrigation with buckets. Beside these systems, there are many other methods for manual irrigation, which are easy to install and simple to use. In general, all of these methods have high self-help compatibility and a relatively high performance. Therefore such systems are also called HELPFUL irrigation methods: High-frequency, Efficient, Low-volume, Partial-area, Farm-Unit, and Low-cost.

Figure 2.6: Manual Irrigation

2.3 Water Resources for Irrigation

The sources of water for irrigation can include surface water sources, groundwater sources, municipal water supplies, grey water sources, and other agricultural and industrial process wastewaters. Surface water sources include flowing water supplies (i.e., creeks, streams, canals) and standing or stored water supplies (i.e., ponds, reservoirs, lakes).

Groundwater supplies may come from springs and wells, and although the quality is usually good, the available quantity that can be pumped at any time may again limit the irrigation method.

Grey-water is domestic wastewater, other than those containing human excreta, such as sink drainage, washing machine discharge or bath water.

The quality of agricultural or industrial process wastewaters often limits their use to surface or sprinkler irrigation methods, and in their suitability for fruits and vegetable crop irrigation.

Irrigation system generally depends on electric pumps to pull the water from the source and push the water out for the field.

2.4 Electric Pumps

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement and gravity pumps.

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines or wind power, pumps come in many sizes, from microscopic for use in medical applications to large industrial pumps.

Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

When in a casing only one impeller is revolving then it is called single stage pump, and when in a casing two or more than two impellers are revolving then it is called double or multi stage pump.

In biology, many different types of chemical and bio-mechanical pumps have evolved, and biomimicry is sometimes used in developing new types of mechanical pumps.

2.5 Pumps Types

Pumps can be classified by their method of displacement into positive displacement pumps, impulse pumps, velocity pumps, gravity pumps, steam pumps and valveless pumps. There are two basic types of pumps: positive displacement and centrifugal. Although axial-flow pumps are frequently classified as a separate type, they have essentially the same operating principles as centrifugal pumps.

2.5.1 Positive displacement pumps

A positive displacement pump makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into the discharge pipe. Some positive displacement pumps use an expanding cavity on the suction side and a decreasing cavity on the discharge side.

Liquid flows into the pump as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant through each cycle of operation. Positive displacement pumps, unlike centrifugal or roto-dynamic pumps, theoretically can produce the same flow at a given speed (RPM) no matter what the discharge pressure. Thus, positive displacement pumps are constant flow machines. However, a slight increase in internal leakage as the pressure increases prevents a truly constant flow rate.

A positive displacement pump must not operate against a closed valve on the discharge side of the pump, because it has no shutoff head like centrifugal pumps. A positive displacement pump operating against a closed discharge valve continues to produce flow and the pressure in the discharge line increases until the line bursts, the pump is severely damaged, or both[4].

A relief or safety valve on the discharge side of the positive displacement pump is therefore necessary. The relief valve can be internal or external. The pump manufacturer normally has the option to supply internal relief or safety valves. The internal valve is usually only used as a safety precaution. An external relief valve in the discharge line, with a return line back to the suction line or supply tank provides increased safety.

A positive displacement pump can be further classified according to the mechanism used to move the fluid to rotary type positive displacement and reciprocating type positive.

- **Rotary type positive pumps**

These pumps move fluid using a rotating mechanism that creates a vacuum that captures and draws in the liquid, rotary pumps are very efficient because they naturally remove air from the lines, eliminating the need to bleed the air from the lines manually.

The nature of the pump requires very close clearances between the rotating pump and the outer edge, making it rotate at a slow, steady speed. If rotary pumps are operated at high speeds, the fluids cause erosion, which eventually causes enlarged clearances that liquid can pass through, which reduces efficiency.

Rotary positive displacement pumps fall into three main types

- First gear pumps as shown in figure (2.7), gear pump is the simplest of rotary positive displacement pump. It consists of two meshed gears that rotate in a closely fitted casing. The tooth spaces trap fluid and force it around the outer periphery. The fluid does not travel back on the meshed part, because the teeth mesh closely in the center. Gear pumps see wide use in car engine oil pumps and in various hydraulic power packs.

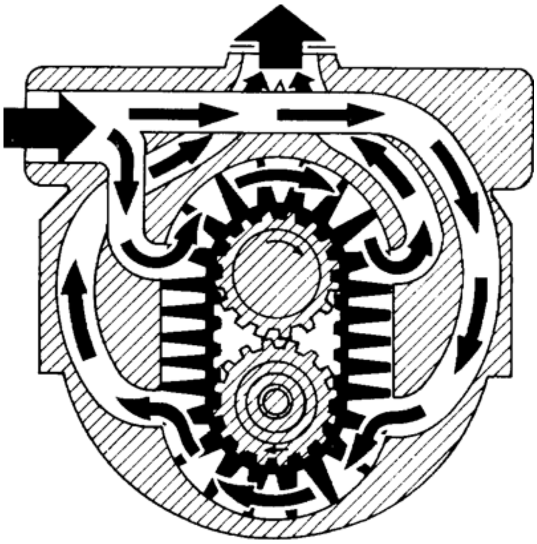

Figure 2.7: Gear Pump

- Second screw pumps as shown in figure(2.8), screw pump is a more complicated type of rotary pump that uses two or three screws with opposing thread, one screw turns clockwise and the other counter clockwise. The screws are mounted on parallel shafts that have gears that mesh so the shafts turn together and everything stays in place. The screws turn on the shafts and drive fluid through the pump. As with other forms of rotary pumps, the clearance between moving parts and the pump's casing is minimal.

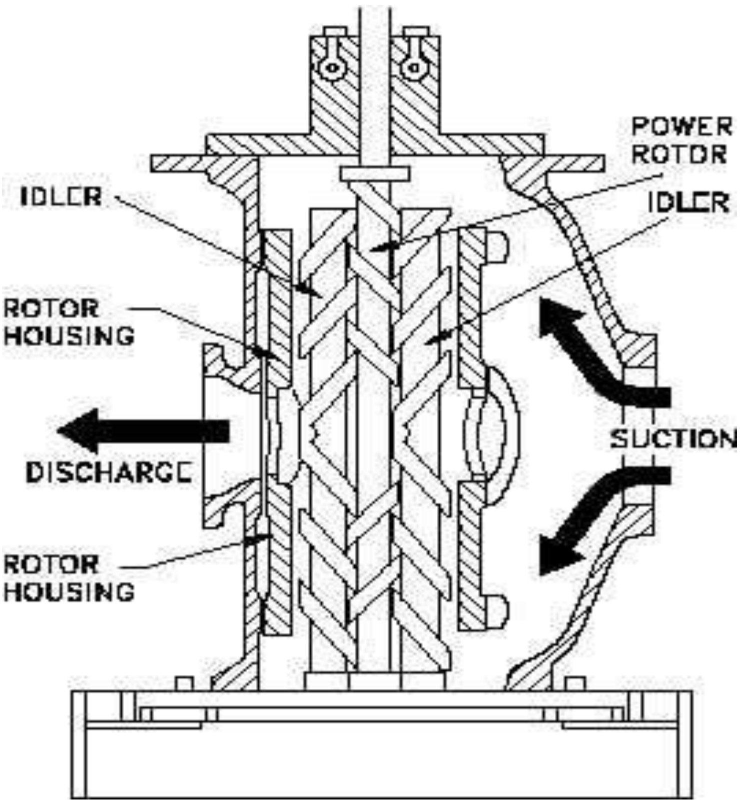

Figure 2.8: Screw Pump

- Third rotary vane pumps, similar to scroll compressors, these have a cylindrical rotor encased in a similarly shaped housing. As the rotor orbits, the vanes trap fluid between the rotor and the casing, drawing the fluid through the pump.

Reciprocating pumps

Reciprocating pump as shown in figure (2.9) move the fluid using one or more oscillating pistons, plungers, or membranes (diaphragms), while valves restrict fluid motion to the desired direction. In order for suction to take place, the pump must first pull the plunger in an outward motion to decrease pressure in the chamber. Once the plunger pushes back, it will increase the pressure chamber and the inward pressure of the plunger will then open the discharge valve and release the fluid into the delivery pipe at a high velocity.

Pumps in this category range from simplex, with one cylinder, to in some cases quad (four) cylinders, or more. Many reciprocating-type pumps are duplex (two) or triplex (three) cylinder. They can be either singleacting with suction during one direction of piston motion and discharge on the other, or double-acting with suction and discharge in both directions. The pumps can be powered manually, by air or steam, or by a belt driven by an engine. This type of pump was used extensively in the 19th century as boiler feed water pumps.

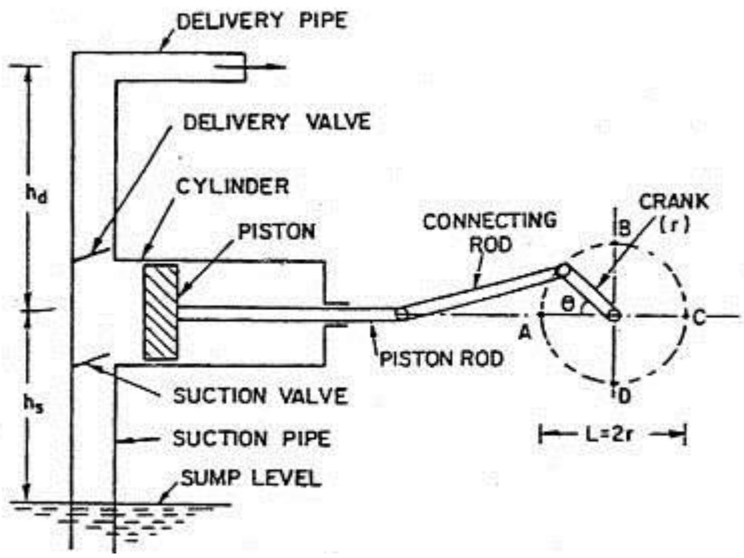

Figure 2.9: Reciprocating Pump

Now reciprocating pumps typically pump highly viscous fluids like concrete and heavy oils, and serve in special applications that demand low flow rates against high resistance. Reciprocating hand pumps were widely used to pump water from wells. Common bicycle pumps and foot pumps for inflation use reciprocating action.

These positive displacement pumps have an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pumps as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant given each cycle of operation.

Reciprocating pumps types are

- Plunger pumps, a reciprocating plunger pushes the fluid through one or two open valves, closed by suction on the way back, in the forward stroke the plunger pushes the liquid out of the discharge valve. Efficiency and common problems: With only one cylinder in plunger pumps, the fluid flow varies between maximum flow when the plunger moves through the middle positions and zero flow when the plunger is at the end positions. A lot of energy is wasted when the fluid is accelerated in the piping system. Vibration and water hammer may be a serious problem. In general the problems are compensated for by using two or more cylinders not working in phase with each other.
- Diaphragm pumps – similar to plunger pumps, where the plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder. Diaphragm valves are used to pump hazardous and toxic fluids.
- Piston pumps displacement pumps – usually simple devices for pumping small amounts of liquid or gel manually. The common hand soap dispenser is such a pump.

2.5.2 Centrifugal pumps

Almost all irrigation pumps fall into this category**.** A centrifugal pump uses an impeller (sort of like a propeller, but a little different) to spin the water rapidly in a casing as shown in figure (2.10). This spinning action moves the water through the pump by means of centrifugal force. Centrifugal pumps may be multi-stage, which means they have more than one impeller and casing, and the water is passed from one impeller to another with an increase in pressure occurring each time. Each impeller/casing combination is referred to as a stage.

All centrifugal pumps must have a wet inlet, that is, there must be water in both the intake (inlet) pipe and the casing when the pump is started. They can't suck water up into the intake pipe. They must be primed by adding water to the intake pipe and case before the first use. To prime them you simply fill the intake pipe with water and then quickly turn on the pump. To put it simply, this type of pump can't suck air, only water, so if there is no water already in the pump it won't pull any water up into it. Once it gets water in it the first time, most centrifugal pumps are designed to hold the water with a small valve so the pump doesn't need to be primed again every time you turn it on.

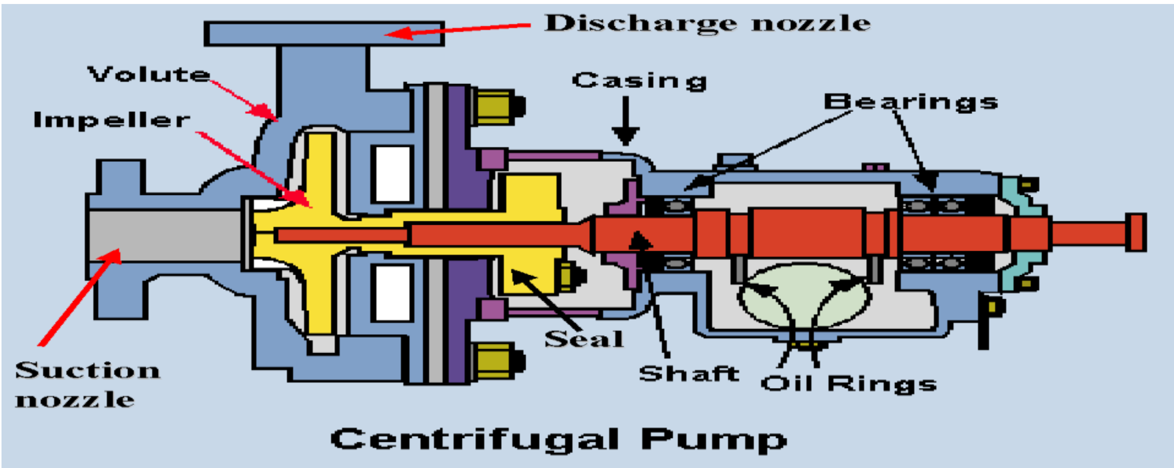

Figure 2.10: Centrifugal Pump

End-Suction centrifugal pumps the most common type of pump it shown in figure (2.11). Typically the pump is close-coupled to an electric motor, that is, the pump is mounted right on the end of the motor's drive shaft and the pump case is bolted straight into the motor so that it looks like a single unit.

The water typically enters the pump through a "suction inlet" centred on one side of the pump, and exits at the top. Almost all portable pumps are end-suction centrifugal type pumps. If the pump isn't one of the next two types, then chances are it is an end-suction centrifugal. End-suction centrifugal pumps generally need to be primed the first time they are used (including many so called self-priming models), after that most will not require priming unless a leak develops in the intake pipe. If the pump needs to be primed each time it is turned on this almost always means there is a tiny leak in the intake pipe.

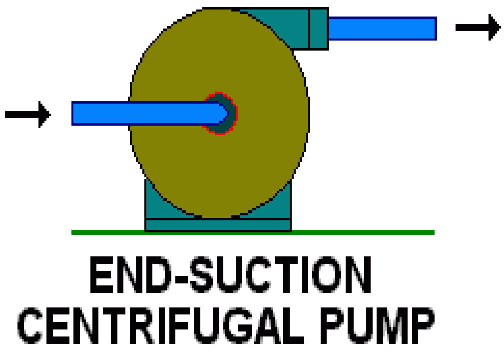

Figure 2.11: End-suction Centrifugal Pump

End-Suction Centrifugal is designed to push water, not pull it. They are great for use as irrigation booster pumps. They are also very good for pumping water from any source where the water level is higher than the pump, where the water can flow down an intake pipe to the pump using gravity. But any time they need to actually suck the water up into the pump they perform much less efficiently. Therefore end-suction centrifugal pumps are not the best choice for drawing water from a water source that is lower than the pump, for example they are not good when mounted on the bank of a pond, stream, river, etc.

When pulling water up into the pump they must be installed as close to the water surface level as possible, which is often inconvenient. Each pump is different, so check with the manufacturer to determine the maximum height the pump can be above the water surface. As a general rule they perform very poorly if they are more than five feet above the water surface. Just remember, end-suction centrifugal pumps are great at pushing water, but they are not good at pulling it.

Rotodynamic pumps (or dynamic pumps) are a type of velocity pump in which kinetic energy is added to the fluid by increasing the flow velocity. This increase in energy is converted to a gain in potential energy (pressure) when the velocity is reduced prior to or as the flow exits the pump into the discharge pipe. This conversion of kinetic energy to pressure is explained by the first law of thermodynamics, or more specifically by Bernoulli's principle.

Dynamic pumps can be further subdivided according to the means in which the velocity gain is achieved, these types of pumps have a number of characteristics: continuous energy, conversion of added energy to increase in kinetic energy (increase in velocity) and conversion of increased velocity (kinetic energy) to an increase in pressure head.

A practical difference between dynamic and positive displacement pumps is how they operate under closed valve conditions. Positive displacement pumps physically displace fluid, so closing a valve downstream of a positive displacement pump produces a continual pressure build up that can cause mechanical failure of pipeline or pump.

Dynamic pumps differ in that they can be safely operated under closed valve conditions (for short periods of time).

Radial-flow pumps such a pump is also referred to as a centrifugal pump. The fluid enters along the axis or center, is accelerated by the impeller and exits at right angles to the shaft (radially); an example is the centrifugal fan, which is commonly used to implement a vacuum cleaner. Generally, a radial-flow pump operates at higher pressures and lower flow rates than an axial- or a mixed-flow pump.

Axial-flow pumps these are also referred to as all fluid pumps. The fluid is pushed outward or inward and move fluid axially. They operate at much lower pressures and higher flow rates than radial-flow (centripetal) pumps. Axial-flow pumps cannot be run up to speed without special precaution. If at a low flow rate, the total head rise and high torque associated with this pipe would mean that the starting torque would have to become a function of acceleration for the whole mass of liquid in the pipe system. If there is a large amount of fluid in the system, accelerate the pump slowly.

Mixed-flow pumps mixed-flow pumps function as a compromise between radial and axial-flow pumps. The fluid experiences both radial acceleration and lift and exits the impeller somewhere between 0 and 90 degrees from the axial direction. As a consequence mixed-flow pumps operate at higher pressures than axial-flow pumps while delivering higher discharges than radial-flow pumps. The exit angle of the flow dictates the pressure head-discharge characteristic in relation to radial and mixed-flow.

Educator-jet pump this uses a jet, often of steam, to create a low pressure. This low pressure sucks in fluid and propels it into a higher pressure region.

Gravity pumps include the syphon and Heron's fountain. The hydraulic ram is also sometimes called a gravity pump; in a gravity pump the water is lifted by gravitational force.

Steam pumps have been for a long time mainly of historical interest. They include any type of pump powered by a steam engine and also piston less pumps such as Thomas Savory's or the Pulsometer steam pump.

Recently there has been a resurgence of interest in low power solar steam pumps for use in smallholder irrigation in developing countries. Previously small steam engines have not been viable because of escalating inefficiencies as vapor engines decrease in size. However the use of modern engineering materials coupled with alternative engine configurations has meant that these types of system are now a cost effective opportunity.

Valve less pumping assists in fluid transport in various biomedical and engineering systems. In a valve less pumping system, no valves (or physical occlusions) are present to regulate the flow direction. The fluid pumping efficiency of a valve less system, however, is not necessarily lower than that having valves. In fact, many fluid-dynamical systems in nature and engineering more or less rely upon valve less pumping to transport the working fluids therein. For instance, blood circulation in the cardiovascular system is maintained to some extent even when the heart's valves fail.

Meanwhile, the embryonic vertebrate heart begins pumping blood long before the development of discernible chambers and valves. In micro fluidics, valve less impedance pumps have been fabricated, and are expected to be particularly suitable for handling sensitive bio fluids. Ink jet printers operating on the piezoelectric transducer principle also use valve less pumping. The pump chamber is emptied through the printing jet due to reduced flow impedance in that direction and refilled by capillary action[5].

CHAPTER THREE

SOLAR ENERGY

3.1 Introduction

The sun is an average star. It has been burning for more than 4-billion years, and it will burn at least that long into the future before erupting into a giant red star, engulfing the earth in the process [1]. It is ninety three million miles from Earth, our sun is 333,000 times the size of our planet. It has a diameter of 865,000 miles, a surface temperature of 5,600°C and a core temperature of 15,000,000°C. It is a huge mass of constant nuclear activity. Directly or indirectly, our sun provides all the power we need to exist and supports all life forms. The sun drives our climate and our weather. Without it, our world would be a frozen wasteland of ice covered rock[6].

3.2 The Nature of Light Energy

The sun's light looks white because it is made up of many different colors that, combined, produce a white light. Each of the visible and invisible radiations of the sun's spectrum has a different energy. Within the visible part of the spectrum (red to violet), red is at the low-energy end and violet is at the high energy end having half again more energy as red light. Light in the infrared region has less energy than that in the visible region.

Light in the ultraviolet region has more than that in the visible region. Visible light represents only a tiny portion of a vast radiation spectrum. Studies of light and similar radiation show that the way in which one light ray interacts with another or other physical objects often can be explained as if light were moving as a wave. For this reason it is useful to characterize light radiation by parameters associated with waves.

3.3 Sun Light Reaching Earth

Each second, the sun turns more than four million tons of its own mass into energy, producing neutrinos and solar radiation, radiated in all directions. A tiny fraction of this energy falls on Earth after a journey of about 150 million kilometers, which takes a little more than eight minutes. Not all of the direct sunlight incident on earth's atmosphere arrives at the earth's surface as shown as figure (3.1). The atmosphere attenuates many parts of the spectrum .

For example, X-rays are almost totally absorbed before reaching the ground. A good percentage of ultraviolet radiation is also filtered out by the atmosphere. Some radiation is reflected back into space. Some is randomly scattered by the atmosphere, which makes the sky look blue. It is valuable to relate the amount of sunlight at the earth's surface to the quantity, or air mass (AM), of atmosphere through which the light must pass. Radiation arriving at the surface of the earth is measured against that reaching the fringes of the atmosphere, where there is no air, and the air mass is zero (AMO).

The light of the high-noon sun (and under further specified conditions) passes through an air mass of one (AM1). The intensity of the sunlight reaching the ground weakens for sun angles approaching the horizon since the rays have more atmosphere, or air mass, to penetrate. The atmosphere is a powerful absorber and can cut the sun's energy reaching the earth by 50% and more.

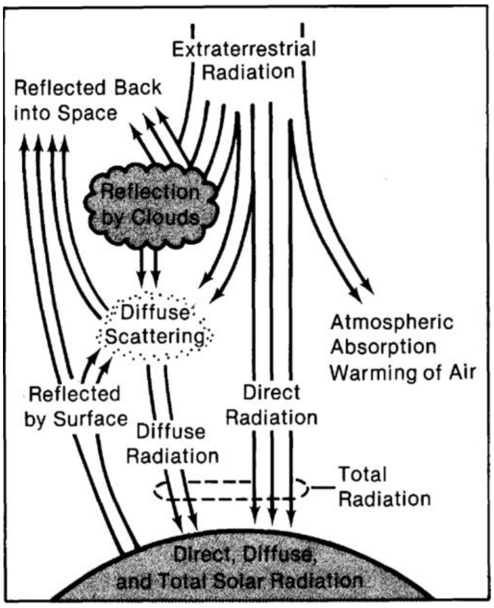

Figure 3.1: Sun Radiation

The sun delivers its energy to us in two main forms as shown in figure (3.2): heat and light. There are two main types of solar power systems, namely, solar thermal systems that trap heat to warm up water, and solar PV systems that convert sunlight directly into electricity[7].

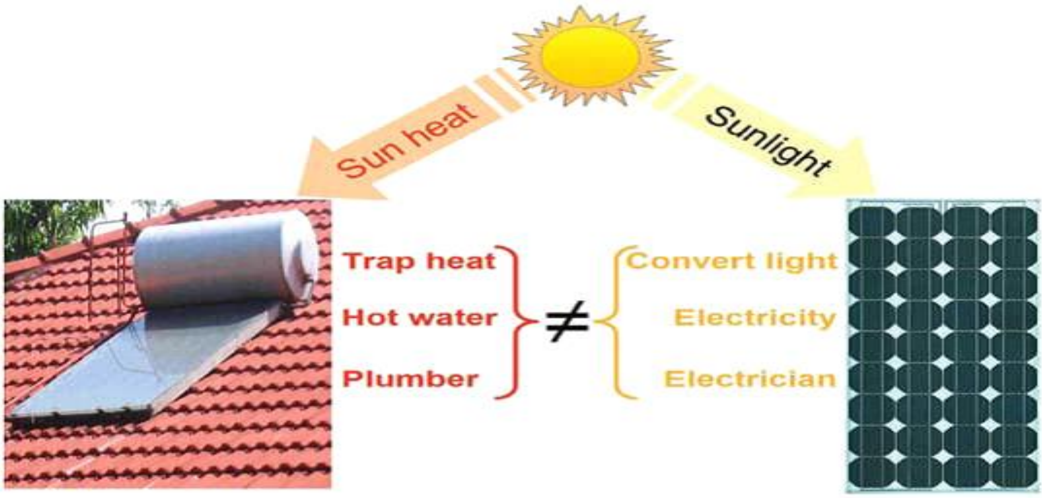

Figure 3.2: Forms of Sun's Energy

As well as architectural designs that rely on solar energy, technologies that can contribute significantly to solving some of world’s most pressing problems today, it seems the sun will be the fuel of the future.

3.4 Photovoltaic

Photovoltaic (photo means light and voltaic means the produces voltage) or the physical phenomenon responsible for converting light to electricity-the photovoltaic effect-was first observed in 1839 by a French physicist, Edmund Becquerel. Becquerel noted a voltage appeared when one of two identical electrodes in a weak conducting solution was illuminated.

The PV effect was first studied in solids, such as selenium, in the 1870s. In the 1880s, selenium photovoltaic cells were built that ex habited 1%-2% efficiency in converting light to electricity. Selenium converts light in the visible part of the sun's spectrum; for this reason, it was quickly adopted by the then-emerging field of photography for photometric (light-measuring) devices. Even today light-sensitive cells on cameras for adjusting shutter speed to match illumination are made of selenium.

Selenium cells have never become practical as energy converters because their cost is too high relative to the tiny amount of power they produce (at 1% efficiency). Meanwhile, work on the physics of PV phenomena has expanded. In the 1920s and 1930s, quantum mechanics laid the theoretical foundation for our present understanding of PV.

A major step forward in solar-cell technology came in the 1940s and early 1950s, when a method (called the Czochralski method) was developed for producing highly pure crystalline silicon. In 1954; work at Bell Telephone Laboratories resulted in a silicon photovoltaic cell with a 4% efficiency. Bell Labs soon bettered this to a 6% and then 11% efficiency, heralding an entirely new era of power-producing cells[8].

- **Photovoltaic Effect**

Photovoltaic (PV) cells are semiconductor devices that enable photons to “knock” electrons out of a molecular lattice, leaving a freed electron and “hole” pair which diffuse in an electric field to separate contacts, generating direct current (DC) electricity in figure (3.3). Photovoltaic cells are interconnected to form PV modules with a power capacity of up to several hundred watts. Photovoltaic modules are then combined to form PV systems.

Photovoltaic systems can be used for on-grid and off-grid applications. Individual PV cells are assembled into modules, several of which can be linked together to provide power in a range of from a few watts to tens or hundreds of megawatts. Off-grid systems may or may not require an electricity storage device such as a battery for back-up power. Some applications, such as solar powered irrigation systems, typically include water reservoirs.

PV systems usually require an inverter, which transforms the direct current (DC) of the PV modules into alternate current (AC), most usages being run on AC. Grid-tied systems similarly require one or several inverters to inject their electrical output into the mains. The components associated with this delivery process, such as inverters, transformers, electrical protection devices, wiring, and monitoring equipment, are all considered part of the "balance of system" (BOS). In addition, the BOS includes structural components for installing PV modules, such as fixed mounting frames and sun-tracking systems.

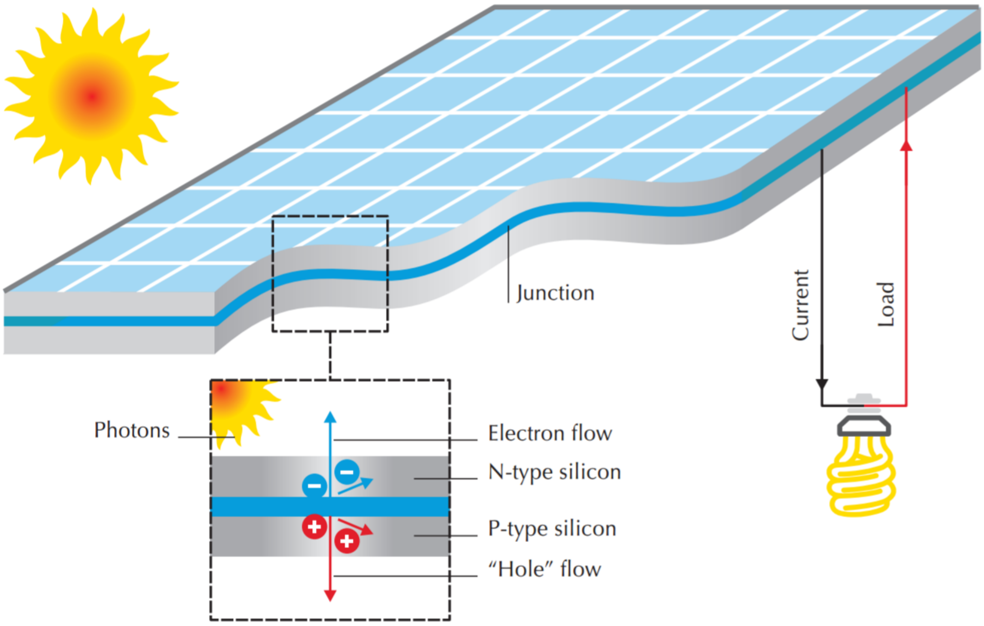

Figure 3.3: The Photovoltaic Effect

3.5 The Principle of A Solar Cell

The working principle of solar cells is based on the photovoltaic effect , i.e. the generation of a potential difference at the junction of two different materials in response to electromagnetic radiation. The photovoltaic effect is closely related to the photoelectric effect, where electrons are emitted from a material that has absorbed light with a frequency above a material-dependent threshold frequency as shown in figure (3.4).

In 1905, Albert Einstein understood that this effect can be explained by assuming that the light consists of well-defined energy quanta, called photons. The energy of such a photon is given by :

$$E=H*V \tag{3.1}$$

Where:

E= photon energy (joule).

H= Planck's constant ($6.62607004*10^{-34}$ m^2.kg/s).

V= frequency of the light(Hz).

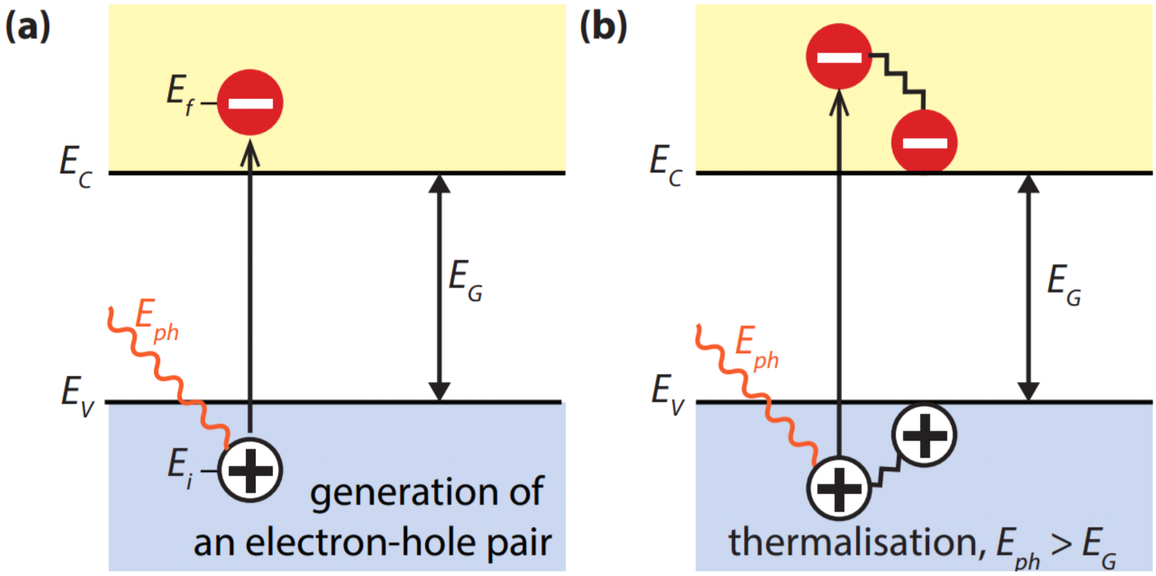

Figure 3.4**:** Effect of Photon on Electrons

In part (a) of figure (3.4) illustrating the absorption of a photon in a semiconductor with bandgap E_g. The photon with energy E_{ph} excites an electron from E_i to E_f . At E_i a hole is created.

In part (b) of figure (3.4) if $E_{ph} > E_g$, a part of the energy is thermalised.

The photovoltaic effect can be divided into three basic processes:

- **Generation of charge carriers due to the absorption of photons in the materials that form a junction:**

Absorption of a photon in a material means that its energy is used to excite an electron from an initial energy level E_i to a higher energy level E_f , as shown in figure (3.4) part (a). Photons can only be absorbed if electron energy levels E_i and E_f are present so that their difference equals to the photon energy, as in equation (3.1).

In an ideal semiconductor electrons can populate energy levels below the so-called valence band edge, E_V, and above the so called conduction band edge, E_C. Between those two bands no allowed energy states exist, which could be populated by electrons. Hence, this energy difference is called the bandgap:

$$E_g = E_C - E_V \tag{3.2}$$

Where:

E_g= Bandgap (Joule).

E_C= Conduction bandgap (Joule).

E_V= Valence bandgap (Joule).

If a photon with an energy smaller than E_g reaches an ideal semiconductor, it will not be absorbed but will traverse the material without interaction. In a real semiconductor, the valence and conduction bands are not flat, but vary depending on the so-called k-vector that describes the crystal momentum of the semiconductor.

If the maximum of the valence band and the minimum of the conduction band occur at the same k-vector, an electron can be excited from the valence to the conduction band without a change in the crystal momentum. Such a semiconductor is called a direct bandgap material. If the electron cannot be excited without changing the crystal momentum, we speak of an indirect bandgap material.

The absorption coefficient in an direct bandgap material is much higher than in an indirect bandgap material, thus the absorber can be much thinner If an electron is excited from E_i to E_f , a void is created at Ei. This void behaves like a particle with a positive elementary charge and is called a hole. The absorption of a photon therefore leads to the creation of an electron-hole pair, as illustrated in figure (3.5).

The radiative energy of the photon is converted to the chemical energy of the electron-hole pair. The maximal conversion efficiency from radiative energy to chemical energy is limited by thermodynamics. This thermodynamic limit lies in between 67% for non-concentrated sunlight and 86% for fully concentrated sunlight .

- **Subsequent separation of the photo-generated charge carriers in the junction:**

Usually, the electron-hole pair will recombine, i.e. the electron will fall back to the initial energy level E_i, as illustrated in figure (3.5) represents (2). The energy will then be released either as photon (radiative recombination) or transferred to other electrons or holes or lattice vibrations (nonradiative recombination). If one wants to use the energy stored in the electron-hole pair for performing work**.**

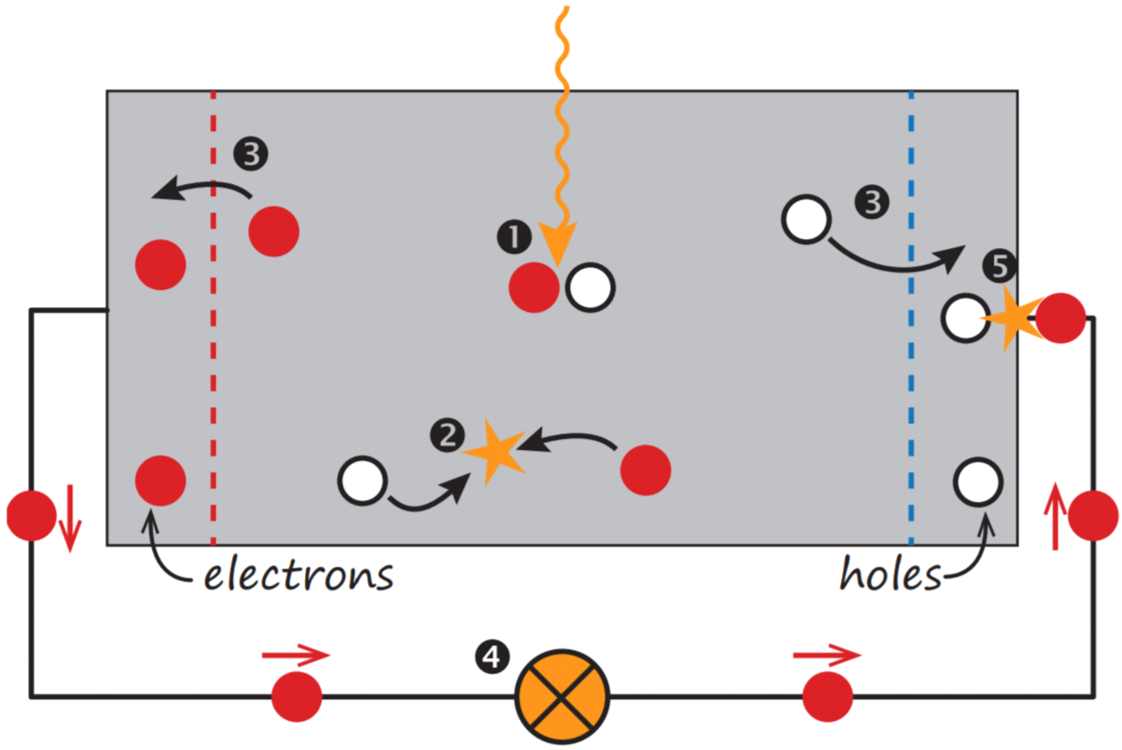

Figure 3.5: A Very Simple Solar Cell Model

Absorption of a photon leads to the generation of an electron-hole pair represents (1). Usually, the electrons and holes will combine represents (2). With semi-permeable membranes the electrons and the holes can be separated

Represents (3). The separated electrons can be used to drive an electric circuit represents (4). After the electrons passed through the circuit, they will recombine with holes represents (5).

In an external circuit, semi-permeable membranes must be present on both sides of the absorber, such that electrons only can flow out through one membrane and holes only can flow out through the other membrane , as illustrated in figure (3.5) represents (3). In most solar cells, these membranes are formed by n- and p-type materials. A solar cell has to be designed such that the electrons and holes can reach the membranes before they recombine, i.e. the time it requires the charge carriers to reach the membranes must be shorter than their lifetime. This requirement limits the thickness of the absorber.

- **Collection of the photo-generated charge carriers at the terminals of the junction:**

Finally, the charge carriers are extracted from the solar cells with electrical contacts so that they can perform work in an external circuit Figure (3.5). The chemical energy of the electron-hole pairs is finally converted to electric energy. After the electrons passed through the circuit, they will recombine with holes at a metal-absorber interface, as illustrated figure (3.5) represents (5)[9].

3.6 Some Types of Photovoltaic (PV) Cells

All photovoltaic (PV) cells consist of two or more thin layers of semi-conducting material, most commonly silicon. When the semiconductor is exposed to light, electrical charges are generated and this can be conducted away by metal contacts as direct current (DC). The electrical output from a single cell is small, so multiple cells are connected together to form a 'string', which produces a direct current.

In many roof-integrated applications, strings are encapsulated (usually behind glass) to form a module (commonly referred to as a 'panel'). The PV panel is the principal building block of a PV system and any number of panels can be connected together to give the desired electrical output. However, two types of PV are best deposited as a thin film, and usually sold encapsulated in a polymer bonded to a substrate that can be used as part of the roofing material.

Here, we only look at commercially available types of PV cell or film, any of which might be found in a module or film used on an active solar roof. We do not consider:

- Gallium Arsenide cells. Due to their toxicity and potential carcinogenic properties, these are only used in rare applications such as satellites or demonstration solar-powered cars.
- Organic-based PV solutions that are still under research.

3.6.1 Monocrystalline silicon PV panels

These are made using cells sliced from a single cylindrical crystal of silicon. This is the most efficient photovoltaic technology, typically converting around 15% of the sun's energy into electricity. The manufacturing process required to produce monocrystalline silicon is complicated, resulting in slightly higher costs than other technologies as shown in figure (3.6).

Advantages

- Monocrystalline solar panels have the highest efficiency rates since they are made out of the highest-grade silicon .The efficiency rates of monocrystalline solar panels are typically 15-20% .

- Monocrystalline silicon solar panels are space-efficient .Since these solar panels yield the highest power output ,they also required the least amount of space compared to any other types
- Monocrystalline solar panels produce up to four times amount of electricity as thin-film solar panels.
- Monocrystalline solar panels live the longest .Most solar panel manufacturers put a 25-year warranty on their monocrystalline solar panels.
- Tend to perform a better than similarly rated polycrystalline solar panels at low-light conditions.

Disadvantages

- Monocrystalline solar panels are the most expensive .
- If the solar panel is partially covered with shade ,dirt or snow, the entire circuit can break down.
- The czochralski process is used to produce monocrystalline silicon .It result in large cylindrical ingots .Four sides are cut out of the ingots to make silicon wafers .A significant amount of the original silicon ends up as waste .
- Monocrystalline solar panels tend to be more efficient in warm weather .Performance suffers as temperature goes up, but less so than polycrystalline solar panels. For most homeowners temperature is not a concern.

Figure 3.6: Monocrystalline

3.6.2 Polycrystalline silicon PV panels

Also sometimes known as multicrystalline cells, polycrystalline silicon cells are made from cells cut from an ingot of melted and recrystallised silicon. The ingots are then saw-cut into very thin wafers and assembled into complete cells. They are generally cheaper to produce than monocrystalline cells, due to the simpler manufacturing process, but they tend to be slightly less efficient, with average efficiencies of around 12% as shown in figure (3.7).

Advantages

- The process used to make polycrystalline silicon is simpler and cost less. The amount of waste is less compared to monocrystalline .
- Polycrystalline solar panels tend to have lower heat tolerance than monocrystalline solar panels .This technically means that they performs slightly worse than monocrystalline solar panels in high temperature .Heat can affect the performance of solar panels and shorten their effect is minor ,and most homeowners do not need to take it into account .

Disadvantages

- The efficiency of polycrystalline based solar panels is typically 13-16% .Because of lower silicon purity ,polycrystalline solar panels are not quite as efficient as monocrystalline solar panels.
- Lower space-efficiency .You generally need to cover a larger surface to output the same electrical power as you would with a monocrystalline solar panels .However this doesn't mean every monocrystalline solar panel perform better than those based on polycrystalline silicon.
- Monocrystalline and thin-film solar panels tend to be more aesthetically pleasing since they have more uniform look compared to the speckled blue color of polycrystalline silicon .

Figure 3.7: Polycrystalline

3.6.3 Thick-film silicon PV panels

This is a variant on multicrystalline technology where the silicon is deposited in a continuous process onto a base material giving a fine grained, sparkling appearance. Like all crystalline PV, it is normally encapsulated in a transparent insulating polymer with a tempered glass cover and then bound into a metal framed module as shown in figure (3.8).

Advantages

- Mass-production is simple .This makes them and potentially cheaper to manufacture than crystalline-based solar cells .
- Their homogenous appearance makes them look more appealing.
- Can be made flexible ,which opens up many new potential applications.
- High temperature and shading have less impact on solar panels performance .
- In situation where space is not an issue ,thin-film solar panels can make sense .

Disadvantages

- Thin-film solar panels are in general not very useful for in most residential situations .They are cheap ,but they also require a lot of space .
- Low-space efficiency also means that the costs of PV-equipment will increase .

- Thin-film solar panels tend to degrade faster than monocrystalline solar panels ,which is why they typically come with a shorter warranty .

Figure 3.8: Thick-film

3.6.4 Amorphous silicon PV panels

Amorphous silicon cells are made by depositing silicon in a thin homogenous layer onto a substrate rather than creating a rigid crystal structure. As amorphous silicon absorbs light more effectively than crystalline silicon, the cells can be thinner - hence its alternative name of 'thin film' PV. Amorphous silicon can be deposited on a wide range of substrates, both rigid and flexible, which makes it ideal for curved surfaces or bonding directly onto roofing materials.

This technology is, however, less efficient than crystalline silicon, with typical efficiencies of around 6%, but it tends to be easier and cheaper to produce. If roof space is not restricted, an amorphous product can be a good option. However, if the maximum output per square meter is required, specifies should choose a crystalline technology.

3.7 Solar Arrays

Single PV cells have limited output. Individual cells can be used to power small, power-miserly equipment such as toys, watches, and pocket calculators. But to provide reasonable power for many practical applications, voltage and amperage outputs from the PV source must be increased.

Individual solar cells have limited power and must be tied together electrically in order to produce enough electricity for most applications. In essence, cells need only be joined to. one another in progressive size levels until their individual power contributions add to that fulfilling a designed need. In practice, certain electrical precautions must be taken in building to desired power levels so that if some cells fail they will not cause failure of an entire assembly.

There are other, non-electrical considerations in producing a PV assembly. They include protection against the assembly's environment (temperature, precipitation, etc...), and waste heat within the assembly itself. Protection from the environment can be achieved by encapsulating. Heat can be transferred away from the assembly by convective, conductive, and radiative means. The heat can also be used for space heating or to produce electricity to supplement that produced by a PV system[8].

3.7.1 PV Building blocks

According to electrical principles, voltages and currents can be increased by suitably connecting power sources. In practice, however, increasing the power levels from photovoltaics is not straightforward and depends on many factors internal and external to the PV cells themselves.

Some of the factors that must be managed are the variability of individual cell energy output and potential problems with the integrity of the connections linking one cell to another. Besides these problems, which are tied to the cell itself, the designer grouping PV cells in a large terrestrial installation must account for uneven illumination-such as caused by cloud shadows, for example.

3.7.2 Boosting voltage and amperage

Ideally, connecting individual cells in parallel-that is, tying a common lead to all positive cell terminals and another lead to all negative terminals-under proper conditions can produce an amperage output from the group of cells that is the sum of that from the individual cells. (There is no voltage increase.) In a very
real sense, combining cells in parallel is equivalent to making a cell larger.

Also under ideal conditions, when solar cells are joined in series-that is, when the positive lead from one cell is joined to the negative of the next, and so on-the voltage contribution from each adds. (The total current available from integrating the cells in this way is no more than from an individual cell). It is possible to gather cells into groups (parallel, current building) and then "string" the groups together (in a series, voltage-building configuration). Or it is possible to gather the cells by stringing them to build the voltage and then grouping the strings to increase amperage as shown in figure (3.9).

There are several structural levels associated with bringing solar cells together. The first, most basic gathering of PV cells is the module, which may integrate fewer than a dozen cells to as many as 100 cells. At the next level is the panel, comprising groups (parallel connections) of modules and/or strings (the series connection of modules or groups). Next is the array, the combining of panels in series and/or parallel arrangements. Last is the array field-a composite of arrays. If the electrical performance of each cell is the same, then it makes no difference how the strings and groups are ordered in achieving a desired output.

Unfortunately, actual cells vary in quality: Even under like conditions of illumination, not all cells behave alike. Inherent cell-to-cell differences are aggravated by uneven illumination. Even worse, if some cells fail and lose their ability to function altogether, they may block current flow like an open electrical switch.

Others break down and become, for all purposes, a simple connecting wire, short-circuiting a part or all of the array. At a minimum, such effects lead to reduced array output. At their extreme, such effects can cause the destruction of an array from overheating.

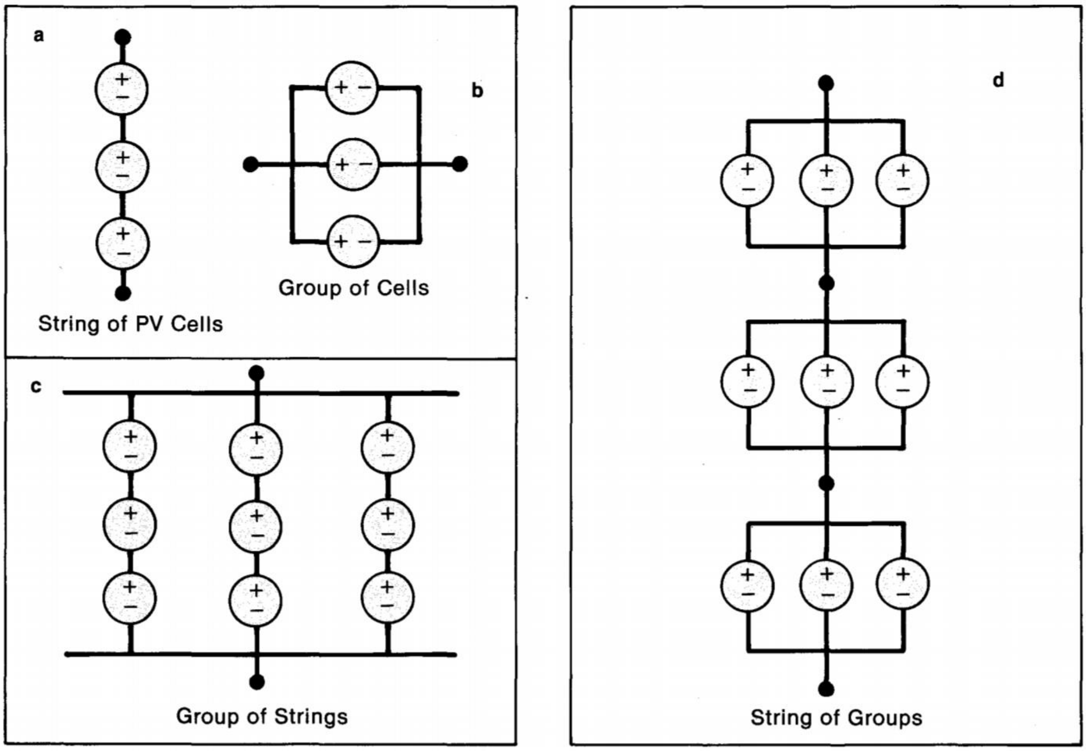

Figure 3.9: Types of Connection For a Simple PV Cells

In part (a) of figure (3.9): Voltage is boosted by stringing cells in a positive-to-negative-to-positive arrangement, while amperage is increased by grouping cells together in parallel in part (b), such that all positive leads are tied, as are all negative leads. Grouping strings together in part (c) or stringing groups in part (d) increases both the voltage and current.

The effect of such breakdowns and some other performance irregularities in a solar array can be minimized by inserting appropriate electronic components into the module circuitry. One precaution against single cell breakdown affecting other areas of the module is to place solid-state diodes (devices that permit electricity to flow in a single direction) either in line with or across a string of cells at appropriate junctures. Placement depends on how the diode is to be used to protect the module figure (3.10).

The use of diodes can cut into electric energy output when all of the module's cells are properly functioning. In such cases they represent an unwanted load. The designer must trade security (adding diodes) against a reduction in output performance[8].

3.7.3 Design Requirements for Connecting Components

Even with ideal cells capturing the sunlight from a cloudless sky, putting individual cells together can present challenges. The sheer numbers needed to build the power levels commonly associated with utility-plant.

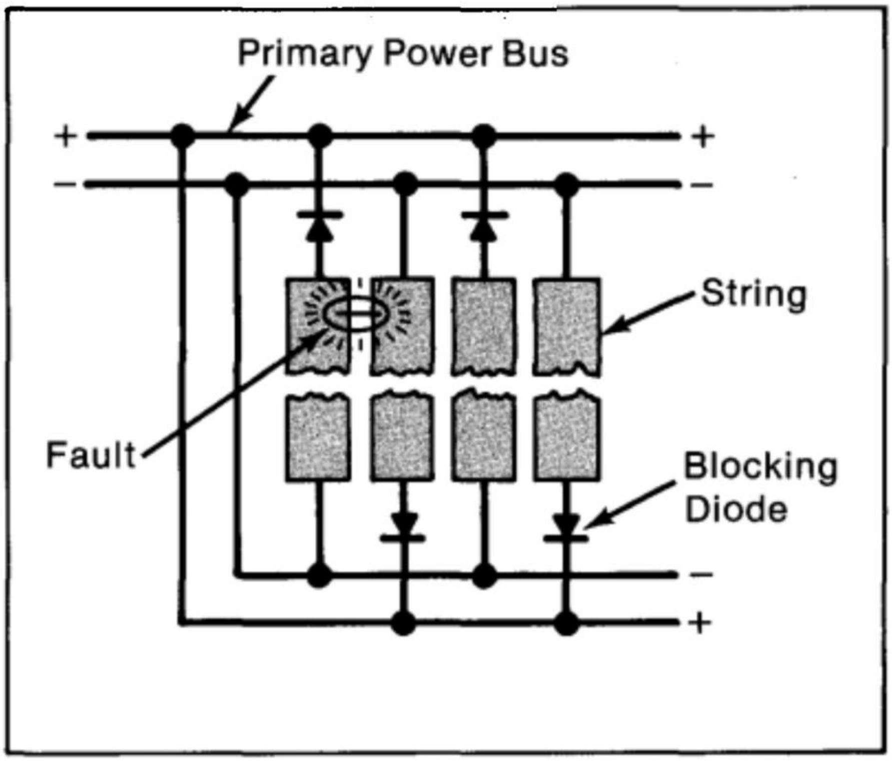

Figure 3.10: Connected PV Arrays

In figure (3.10): Blocking diodes are used to avert failure, such as when a short-circuit fault occurs between adjacent strings of solar cells. Without the diodes, the primary bus would sustain severe damage. output create design problems. Simply joining cells into a large enough matrix to provide 100 megawatts would create a PV system configuration measuring more than several square kilometers, including space between arrays and that for auxiliary equipment. The designer will be expected to confront electrical, mechanical, and other design considerations in putting together such a configuration[8].

CHAPTER FOUR

SYSTEM IMPLEMENTATION

4.1 Introduction

In irrigation control system, solar energy is used to power pump and controller as shown in the block diagram figure (4.1). Soil moisture sensor is put on the soil to read humidity and a relay used to interface the pump.

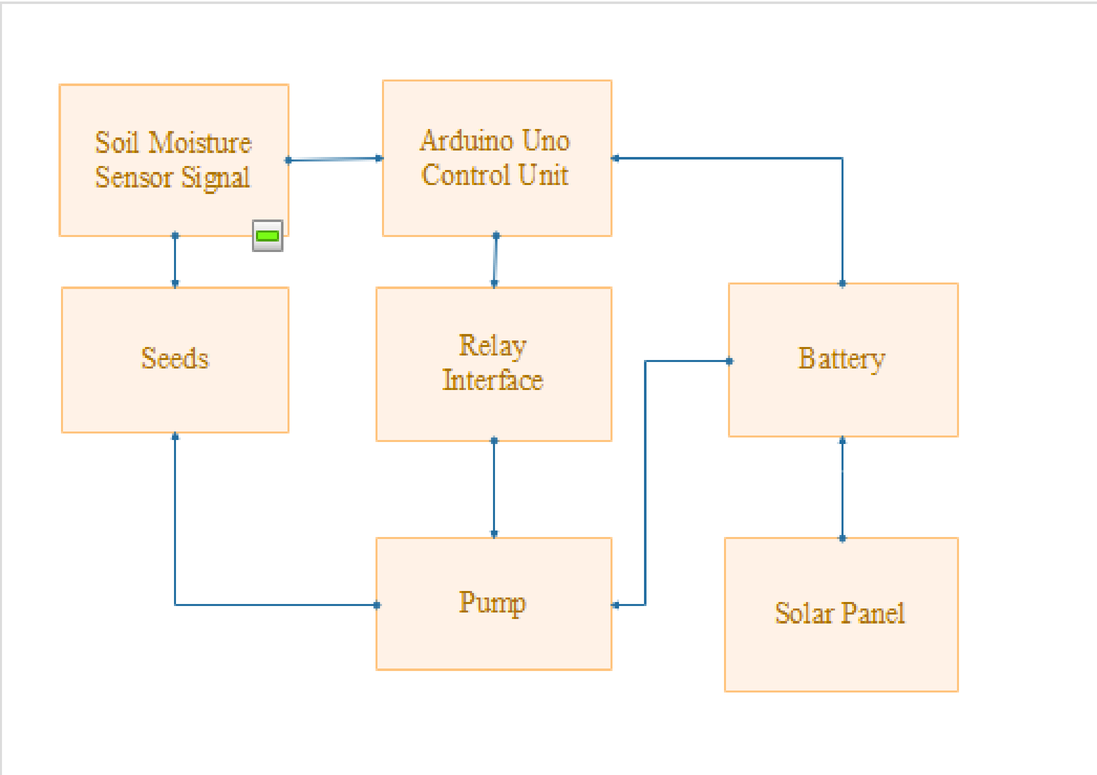

Figure 4.1: Block diagram of the system

4.2 System Components

System practical model consists of Arduino Uno, Sealed Lead Acid Battery, DC Pump, Solar panel, Relay Module, Breadboard and Soil sensor.

4.2.1 Arduino Uno

Arduino Uno as shown in figure (4.2) and figure (4.3) is a microcontroller board based on ATmega 328P microcontroller. It has 14 digital input/output pins (of which 6 can be used as pulse width modulation (PWM) outputs), 6 analog inputs, a 16MHz quartz crystal, a USB connection, a power jack, header and a reset button.

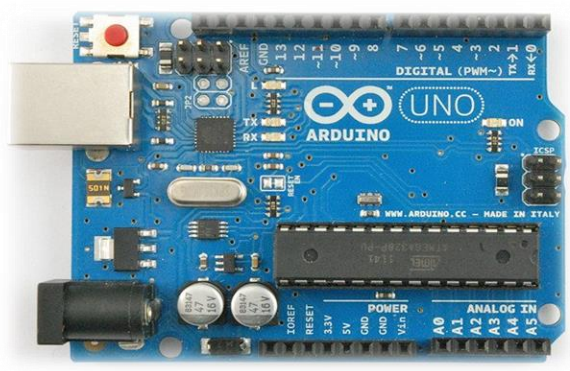

Figure 4.2: Arduino Uno

It used to control all the system by receiving the analog signal from the soil moisture sensor and compare to the ideal analog signal, which it is the perfect humidity of the soil. If the signal is bigger than it, the Arduino will send signal to relay and the pump will be operated.

Specifications:

- Operating Voltage: 5V.
- Input Voltage (recommended): 7-12V.
- Input Voltage (limits): 6-20V.
- DC Current per I/O Pin: 40 mA.

- DC Current for 3.3V Pin: 50 mA.
- Clock Speed: 16 MHz

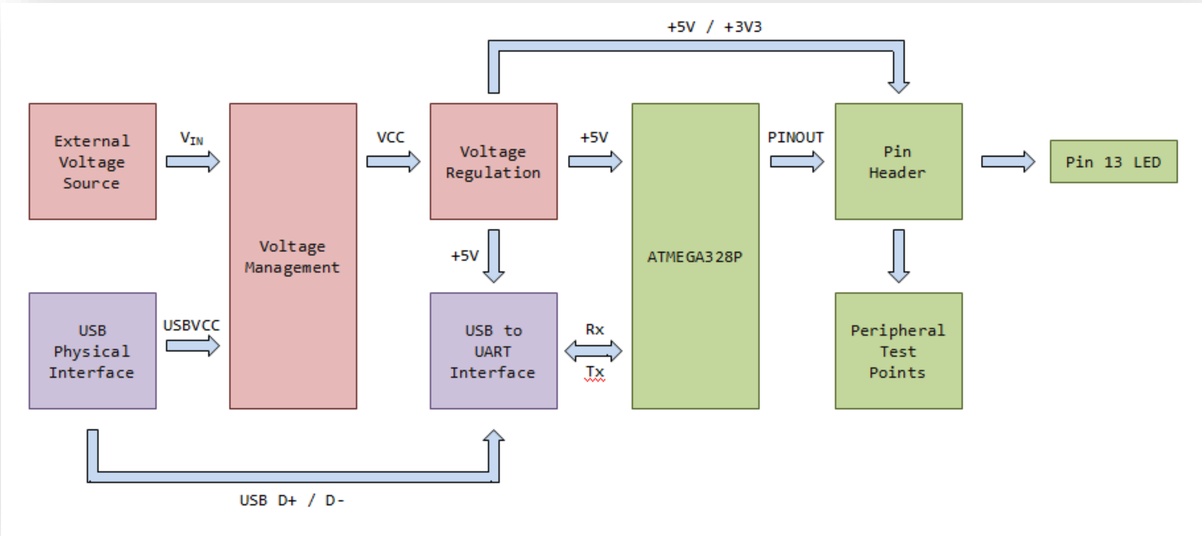

Figure 4.3: Arduino Uno block diagram

4.2.2 DC pump

DC pump as shown in figure (4.4) is used to increase to water pressure and irrigate the plants, it will operate when the signal come from the Arduino to relay.

Specifications:

- Working Voltage: DC12V.
- Working Current: 0.5-0.7A.
- Max Suction: 2m.
- Lift: Vertical up to 3 meters.
- Power: 5-10w.

Figure 4.4: DC Pump

4.2.3 Soil moisture sensor

Soil moisture sensor as shown in figure (4.5) is used to measure the volumetric water content of soil and send it to Arduino, it consist of four pins:

- VCC: for power.
- A0: analog output.
- D0: digital output.
- GND: ground.

The senor analog readings is from 0 to 1023, and it’s digital readings is from 0-100.

Specifications

- Input Voltage: 3.3-5V.
- Output Voltage: 0-4.2V.
- Input Current: 35mA.
- Output signal: both analog and digital.

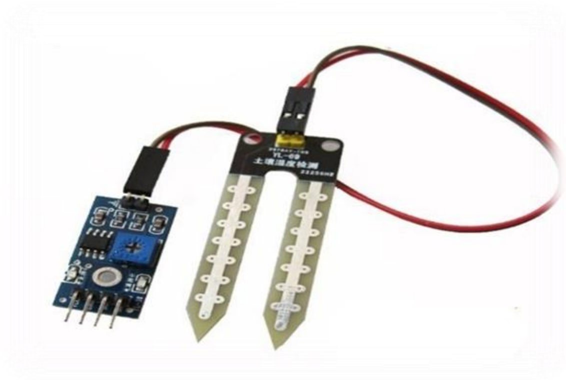

Figure 4.5: Soil Moisture Sensor

The table (4.1) below show the analog readings of the sensor in different conditions:

Condition	**Minimum**	**Maximum**
Dry Soil	700	1023
Humid Soil	300	700
In Water	0	300

Table 4.1: Senor Readings in Different Conditions.

4.2.4 Sealed lead acid battery

Sealed lead acid battery as shown in figure (4.6) is a lead acid battery that has the sulfuric acid electrolyte coagulated so it can not spell out. They are partially sealed, but have vents in case gases are accidentally released for example by overcharging. It used to power the Arduino and the DC pump. It well be charged from the solar plant.

Figure 4.6: SLA Battery

Specifications:

- Cells Per Unit: 6.
- Voltage Per Unit: 12V.
- Capacity: 7.0Ah at 20hr-rate to 1.75V cell at 25C.
- Max.Discharge Current : 70A(5sec)
- Recommended Maximum Charging Current Limit: 2.1A.
- Weight: 2.15 Kg.

4.1.5 Breadboard

Breadboard as shown in figure (4.7) is a thin plastic board used to hold electronic components (transistor, chips, etc...) that are wired together.

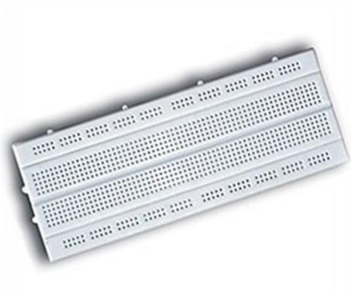

Figure 4.7: Breadboard

Specifications:

- Model: GL-12.
- Dimension (l-w-h) in mm: 172-65-10.
- Tie Points: 840.
- Weight: 130grams.
- Group of 5 connected terminals.
- Bus f 25 connected terminals.

4.1.6 Relay module

Relay module as shown in figure (4.8) is used to control high-voltage electrical devices. It can be used in interactive projects and can also be used to control the lighting, electrical and other equipment's.

It can be controlled directly by a wide range of microcontrollers and can be controlled through the digital IO ports. It used to control the DC pump by receiving the signal from Arduino to operate or stop it. The coil will energize when it receive LOW signal and the NO will changed into NC and the opposite is correct.

Figure 4.8: Relay Module

Specifications:

- Number of I/O Channels: 1.
- Type: Digital.
- Control Signal: 5-12 V TTL Level.
- Max.Allowable Voltage: 250VAC/110VDC.
- Indication LED for Relay's Status.

4.1.7 Solar panel

Solar panels as shown in figure (4.9) absorb the sunlight as a source of energy to generate electricity or heat. I used to charge the SLA battery.

Figure 4.9: Solar Panel

Specifications:

- Type: 10-36P.
- Peak Power: 10W.
- Open circuit voltage: 21.6V.
- Short circuit voltage: 0.65A.

- Max.Power Voltage: 17.3V.
- Max.Power Current: 0.59A.
- Maximum system voltage: 1000V.
- Power tolerance: 3%.
- Dimension (mm): 255x355x17.

TO choose solar panel the total consumed day power must be calculated, as shown in table (4.2):

Tool	Watts Per Hour	Watts Per Day	Working Hours
Arduino	0.23	56.58	24
Relay	0.45	10.8	24
Sensor	0.25	6	24
Pump	10	60	6
Total	10.93	133.38	

Table 4.2: Power Calculations

The total consumed power is 133.38 watt per day, and then the solar panel calculations are:

$$S = (T/H) + M \qquad (4.1)$$

Where:

S=Solar panel that needed to operate the system.

T=Total consumed power.

H=Daylight hours.

M=Power tolerance (10% of T/M).

S=(133.38/6)+(0.1*133.38/6)

S= 24.453

The needed solar panel is 25 watt panel.

4.3 Schematic Diagram

A Program which used to draw the schematic diagram of the system is called fritzing. It is an open source hardware initiative that allow the user to create and plan circuits out before creating them. The program comes with a bunch of pre-loaded circuits boards from different companies such as Arduino and Spark fun.

The figure (4.10) is showing the schematic diagram of the system, solar model and battery is replaced by battery; because there is no sketching program can represent it.

Breadboard's first bus is connected to the Arduino's 5v pin, and the second breadboard's bus is connected to the Arduino's GND pin.

The sensor has four pins VCC, GND, A0 and D0. The VCC is connected to breadboard's first bus and GND is connected to breadboard's second bus. A0 is connected to Arduino's analog pin 0 (A0) as an input signal to read the soil status and send it to Arduino.

Relay's VCC pin is connected to breadboard's first bus to supply power to it, and it's GND pin is connected to breadboard's second bus.

The Arduino is powered by the SLA battery which is providing 12 VDC to it. The digital IO pin 1 is connected to the IN relay's pin and COM pin is connected to positive side of battery.

The pump positive side is connected to NO relay's pin and the negative is connected to the negative side of battery. Also the battery is charged by the solar panel.

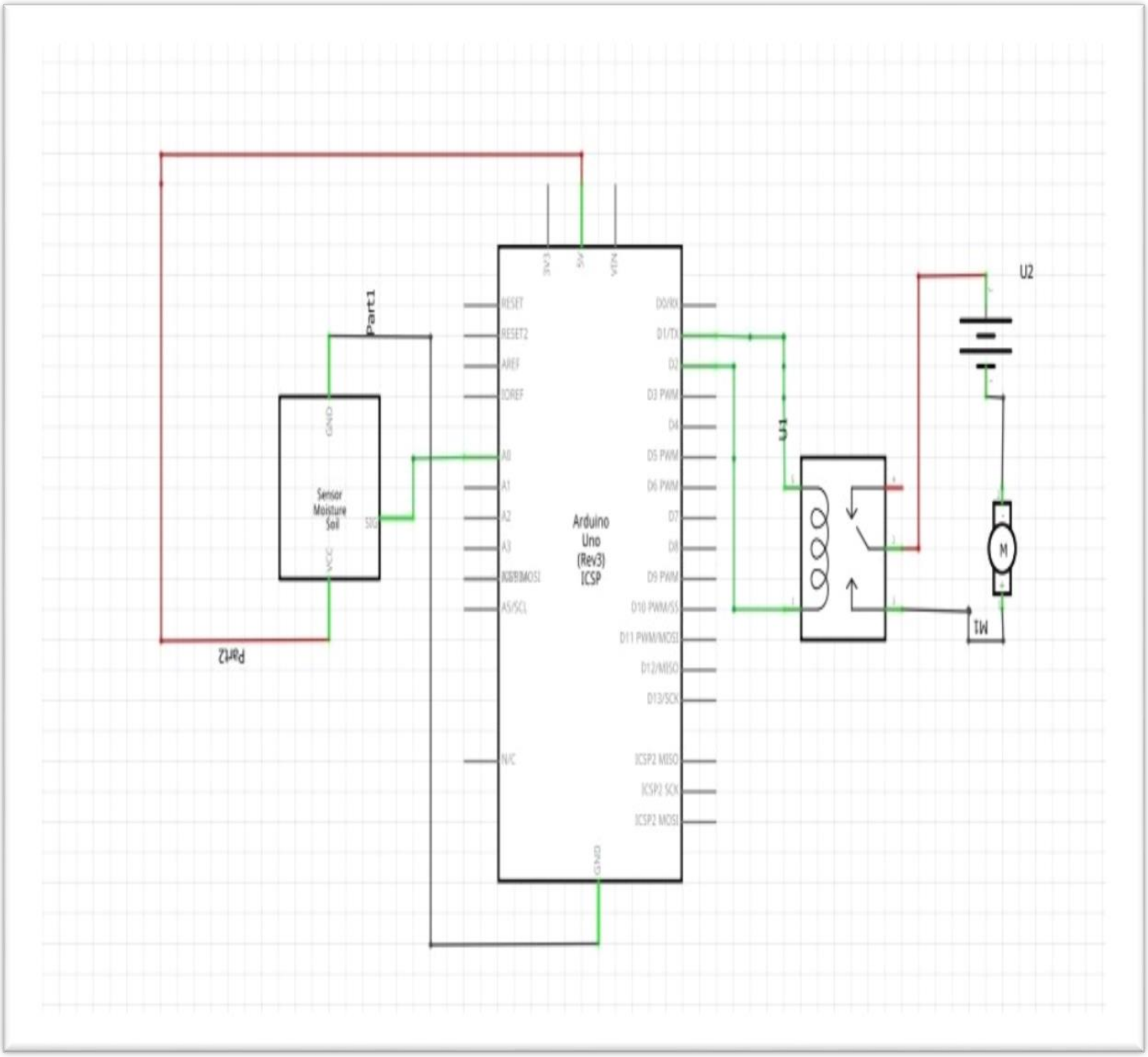

Figure 4.10: Schematic Diagram Of The System

4.4 System Operations

In the normal condition where the soil is at perfect humidity according to sensor signal which is sent to Arduino, the pump will not operate. When the sensor analog reading is bigger than 500, the Arduino will send LOW signal through digital pin1 (D1) to relay's IN pin which will energize the coil and turn the NO side into NC and the pump will be operated.

The pump will stay operating until the sensor send analog signal smaller than 400, then the Arduino will send HIGH signal through digital pin1 (D1) to relay’s IN pin which will de energize the relay’s coil and the pump will stop operating.

4.5 System Code

```
cost in pin First=1;
cost in pinSensor=A0;
in analogS=0;
void setup() {
pinMode(pinFirst,OUTPUT);
pinMode(pinSensor,INPUT);
}
void loop() {
  analogS=analogRead(pinSensor);
  if (analogS > 400)
  {
  digitalWrite(pinFirst,LOW);
  delay(100);
  }
else
{digitalWrite(pinFirst,HIGH);
delay(100);  }
```

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The main goal of the project is to implement system that adjust the perfect humidity to seeds and provides enough energy to operate the pumps. The project is chosen to irrigate seeds without human contribution and to providing farms with solar energy.

The design has been developed successfully by using Firitzing app and the humidity of seed's soil is adjusted by soil moisture sensor which the pump is controlled by it. As a result of the project, the running cost of irrigation has been reduced and the physical effort that used in irrigation by farmers is saved. Also the quality of the seeds is improved by adjusting the perfect conditions to the soil.

5.2 Recommendations

To increase the system usefulness, some ideas are considered for further improvement such as:

- Adding machines to pesticide the seeds
- Design draining system to drain the floodwater.
- Implement harvesting machine to harvest the seeds.

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