# Design of Solar Power Based Water Pumping System

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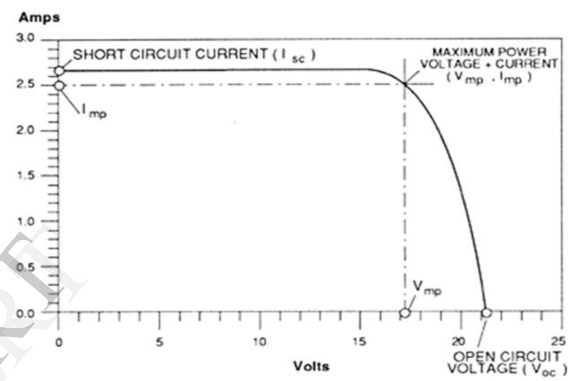
***Abstract:***

*Day by day the use of non-renewable energies have been increased a lot and now they are becoming extinct.The raw materials used to generate power i.e. coal,fossil fuels have been depleting very rapidly.People have been suffering a lot due to immense power cuts. To get out of these problems we are going for the renewable energies like solar,wind,biomass etc. As agriculture is heart of a country and every individual depend on agriculture for food. Farmers have been facing horrible problems due to power cuts. Our paper is a solution for this problem.We are now coming up with the design of "Solar power based water pumping system".*

***Keywords:*** *Solarpanels, rechargeable batteries,buck converter, boost chopper, submersible motor.*

**Introduction:**

Solarenergy,radiant light and heat from the sun, has been harnessed by humans since ancient timesusing a range of ever-evolving technologies.The early development of solar technologies starting in the 1860s was driven by an expectation that coal would soon become scarce. However, development of solartechnologies stagnated in the early 20th century in the face of the increasing availability, economy, and utility of coal and petroleum.Cedric Philibert, senior analyst in the renewable energy division at the IEA said: "Photovoltaic and solar-thermal plants may meet most of the world's demand for electricity by 2060 and half of all energy needs with wind, hydropower and biomass plants supplying much of the remaining generation". "Photovoltaic and concentrated solar power together can become the major source of electricity".




Characteristics of PV Cell



A one kilowatt PV system each month:

- ✓ prevents 150 lbs. of coal from being mined
- ✓ prevents 300 lbs. of CO2 from entering the atmosphere
- ✓ keeps 105 gallons of water from being consumed
- ✓ keeps NO and SO2 from being released into the environment
- ✓ *in Colorado, or an equivalent system that produces 150 kWh per month

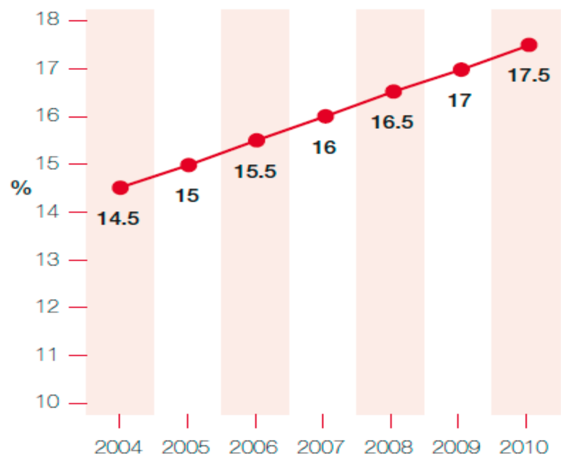



Fig:Year and growth phenomena

## DESIGN AND PERFORMANCE ANALYSIS OF THE SOLAR PV DC WATER PUMPING SYSTEM

A solar water pumping system is designed with solar photovoltaic panels and locally available electric pumps. All components in the system design have been procured locally except solar panels. A DC-DC Buck converter is used to integrate with the solar water pumping system to operate it efficiently. Themicrocontroller based solar tracking system has incorporated in order to attain maximum solar power for electricity generation and thereby increasing the system efficiency.

## SOLAR WATER PUMPING SYSTEM:

The solar-powered pumping system can be used anywhere but it is appropriate for rural areas of India which is facing energy crisis like other developing countries of the world. However due to geographical position, India has ample sunshine through the year which makes it ideal location for utilization of solar energy. Small farms, villages, and animal herds in developing countries require hydraulic output power of less than a kilowatt. Many of these potential users are too far from an electrical grid to economically tap that source of power, and engine-driven pumping tends to be prohibitively expensive as well as unreliable due to the high cost of purchased fuel and insufficient maintenance and repair capabilities. Though the installation cost of solar powered pumping system is more than that of gas, diesel, or propane-powered generator based pumping system but it requires far less maintenance cost. However by comparing installation costs (including labor), fuel costs and maintenance costs over 10 years with other conventional fuel based pumping system, the solar PV water pumping system can be a suitable alternate option. This system has the added advantage of storing water for use when the sun is not shining,eliminating the need for batteries, simplicity and reducing overall system costs. Solar water pumps are designed to use the direct current (DC) provided by a PV array, although some newer versions use a variable frequency AC motor and a three-phase AC pump controller that enables them to be powered directly by the solar modules. Since solar cell is expensive and its electricity production is of intermittent nature therefore solar pumps need to be as efficient as possible i.e. they need to maximize the gallons of water pumped per watt of electricity used.

The long-term cost analysis makes the solar PV pumping system comparable to most other remote watering options in the rural areas. The lifetime of solar water pump is usually 20 years, which ultimately is lower than the life span period cost compared to the conventional pumps. By using solar PV pumps, load on the grid system can be reduced and the subsidy on the diesel can be lowered.



## COMPONENETS USED FOR THE DESIGNED SYSTEM:

1. Solar Panel
2. Chopper
3. Battery
4. D C Motor
5. Connector

In Components are sized accordingly and then connected directly with the panels to examine the converter design.

## SOLAR PANEL AND ARRAY:

There are different sizes of PV modules commercially available. For the proposed system, solar panels are used. The specifications of the solar panels are provided below:

Rated Current: 7amps
Rated Voltage: 24volts
Short Circuit (SC) Current: 8.07amp
Open Circuit (OC) Voltage: 42volt

Cell Temperature: 25°c

Six 250Wp solar panels have been used to provide DC power supply for the water pumping system. Such 6 solar panels supply 1500Wp power during the normal condition. The solar panels are connected in two arrays, the first, second arrays and 6 panels. All six panels are connected in parallel to provide power supply to the pumping system.

## RATINGS OF SOLAR PANEL(STAND-ALONE SYSTEM):

- 1500W
- Inverter set
- Charge regulators
- FF~70%
- Efficiency =15-20%
- Tolerance =-3 to +15
- V max =34v
- Vo c =42v
- Imax =7A
- Is c =7.05A
- UPS back up
- Battery of 1800 Ah

## BATTERY COUPLED SOLAR WATER PUMP

Here we are using battery-coupled water pumping systems. It consist of photovoltaic (PV) panels, charge control regulator, batteries, pump controller, pressure switch and tank and DC water pump which is shown in figure1. The electric current produced by PV panels during daylight hours charges the batteries and the batteries in turn supply power to the pump anytime whenever the water is needed.

## DC SOLAR PUMP

The DC solar pump (DCSP) is widely used throughout the world today. The DCSP operates in a very simple mechanism. Figure 4 shows the basic connection diagram of a DCSP. In the proposed photovoltaic water pumping system, the solar panels are directly connected to a DC motor that drives the water pump. For such simplified systems, DC motors and centrifugal pumps are required, because of their ability to be matched to the output of the solar panels. Volumetric pumps, often referred to as positive displacement pumps, have completely different torque-speed characteristics and are not well suited to being directly coupled to solar panels. Similarly, a range of motor types is used for water pumping systems, including DC series motors, DC permanent magnet motors, DC permanent magnet brushlessmotors, AC asynchronous induction motors and AC synchronous motors. For AC motors, an inverter is to be included between the solar panels and the motor.

For the proposed design, a DC motor and a centrifugal pump are used for the solar water pumping system. Initially this system is implemented without power conditioning unit (PCU) to observe the performance of the pumping system. Later a buck converter is incorporated with the designed system to supply initial high current for starting of the motor.

## DC - DC CONVERTER

A dc to DC-to-DC converter is a device that accepts a DC input voltage and produces a DC output voltage. Typically the output produced is at a different voltage level than the input. Besides thereare SMPS configurations which can step up, step down voltages with precise voltage regulation. In this design the buckconverter is used forcurrent boosting by stepping down the voltage for staring of the DC motor.

## BOOST CONVERTER:

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

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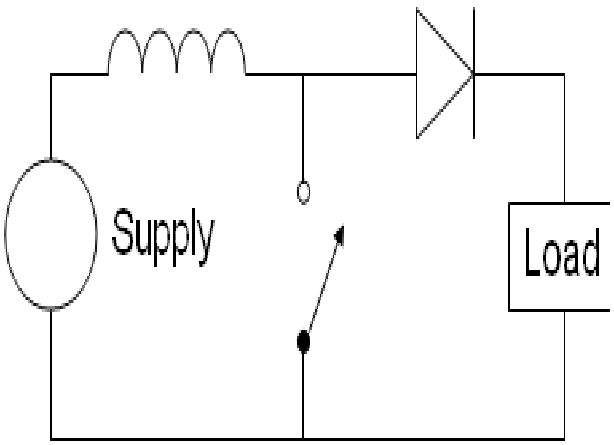



Fig : Boost Chopper

The typical buck converter circuit is shown in the figure below.

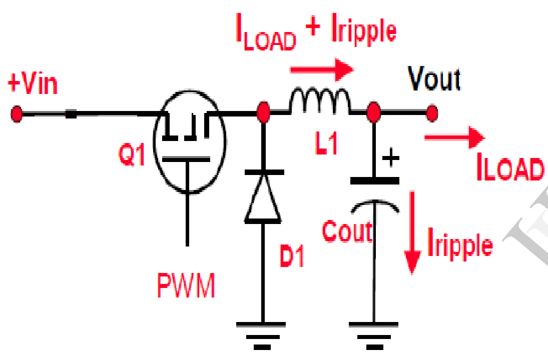



Fig : Buck Chopper

**DC-DC BUCK CHOPPER**

Input and output voltage values as well as the switching frequency needs to be fixed at the very first of the designing process. The assumptions which are considered for the design are as follows,

VIn = 24volts,

VOut = 12volts,

Fswitching =50 Hz

Duty Cycle, D=0.01 ,

(1) Calculation of the Inductor

Starting with the basic equation for current flow through an inductor:

V = L (di/dt)…………… (1)

Or, L = V (dt/di )………. (2)

Rearrange and substitute:

L = (Vin – Vout) · (D / Fsw ) / Iripple………….. (3)

(2) Calculation of the Capacitor

The peak-to-peak ripple voltage of the capacitor is defined as:

dVc= di/ (8* Fsw * Cout)……… (4)

Rearranging the terms to calculate "Cout" and the equation changes to:

Cout= di/ (8* Fsw *dVc )……….. (5)

Assuming dVc = 2.3 mV, the value of Cout is obtained as:

Cout= .117 / (8* 30 KHz * 2.3 mV)

So, Cout= 211 μF

(3) Selection of the diode

The maximum Diode Current needs to be analyzed first:

Id = (1-D) · ILOAD

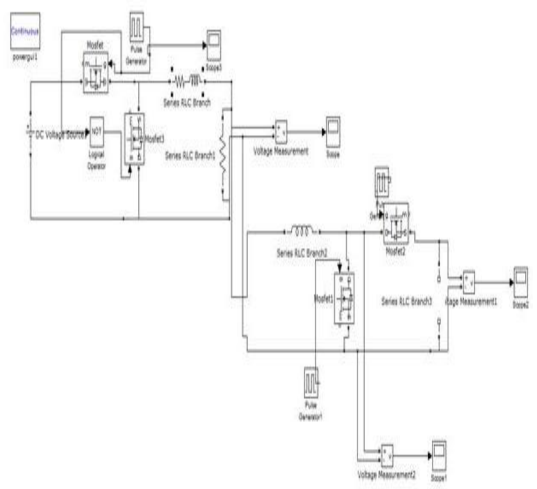
So, Id = (1.0- 0.705) 51.42 = 15.1689A

In order to achieve the required Id, 10 diodes of 12 V and 5 A rating are connected in parallel for the designed DC-DC converter.

(4) Selection of the MOSFET

Traditional Power MOSFETs are chosen whose gate pulse is provided from SMPS (Switch Mode Power Supply) circuit. Six power MOSFETs are connected in parallel to operate under a high current. The MOSFETs are switched synchronously from the pulse of SMPS to control voltage regulation of the DC-DC converter. SG3524 IC is used for designing the SMPS. Thesystem frequency of the SMPS is kept at 30 kHz.

The circuit diagram of the SMPS IC is given in the figure



We have Ideal Voltage measurement.

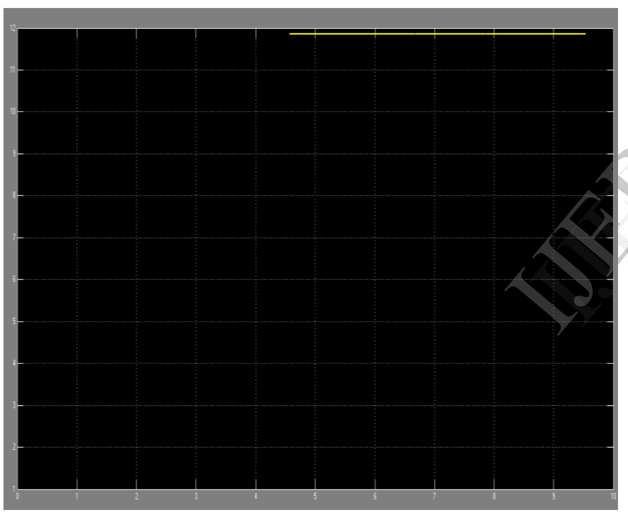


Fig : Buck Chopper Simulation Output

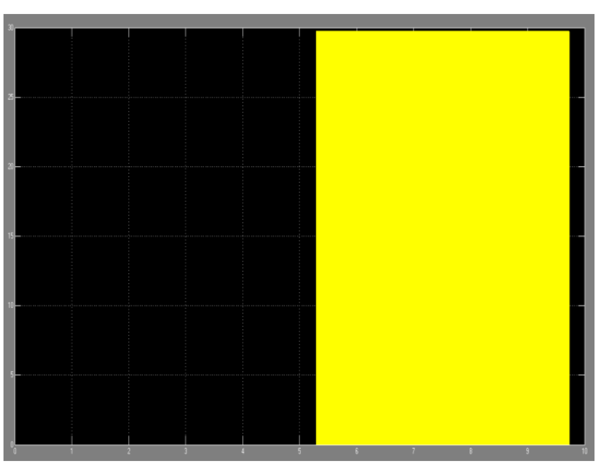


Fig : Boost Chopper Simulation Output

**BATTERY:**

A battery is an electrochemical device that converts the chemical energy contained in it's active material directly into electrical energy and vice versa by means of oxidation-reduction reactions

Batteries are mainly used to supply energy on demand

Batteries are one of the most sensitive equipment of a PV system and expensive too, accounting for nearly 20% to 40% of the total cost of the PV system

Batteries are mainly used for 2 purposes:

1. As solar power is not available during nights and cloudy days, we need to store the energy produced during the daytime
2. for stand-alone applications

The most commonly used batteries in the PV systems are the lead-acid and nickel cadmium batteries. But we use the lead-acid battery, on account of its low cost and simple charging process. The specification of the battery that we use is 180ah



Calculation for the number of batteries that we use in our project

- Generally the sun gives 1000W/sq.mt
- A solar panel is 15% efficient

So we get 150 W (15% of 1000)

Panel size=10*10

[1sq.m=10.7sq.ft]

10sq.m=107sq.ft

=>10sq.m=10.344

We use 6 panels each of 250 watts (250*6=1500)

The size of the motor that we use is 1hp (750 watts)

(Watts)

750*5=3750 w-hr

Usually battery is specified in amp-hr

The specification of the battery that we use is 180Ah

- We require 3750/.8=4687.5 whr
- .8 is efficiency of motor

- We use 12v battery so 4687.5/12=390.62Ah
- Battery energy stored 390.62/180*.6=3.66 (Since battery is 60% efficient)
- We require 4 batteries to supply power to load for 4-5 hrs.

## ENERGY PAY BACK TIME:

EPBT is the time necessary for a photovoltaic panel to generate the energy equivalent to that used to produce it.

A ratio of total energy used to manufacture a PV module to average daily energy of a PV system.

At present the Energy payback time for PV systems is in the range 8 to 11 years, compared with typical system lifetimes of around 30 years. About 60% of the embodied energy is due to the silicon wafers.

## PV'NOMICS

- Module costs typically represents only 40-60% of total PV system cost and the rest is accounted by inverter, PV array support, electrical cabling and installation
- Most PV solar technologies rely on semiconductor-grade crystalline-silicon wafers, which are expensive to produce compared with other energy sources
- The high initial cost of the equipment they require discourages their large-scale commercialization
- Initial cost of system
- 1 watt = Rs. 95.50
- Total system wattage 1500
- 1500 x 95.50= Rs. 143250
- 1.5 kw means 1.5 unit
- According to government rules 1 unit cost for commercial purpose is Rs. 13
- In one day this system works for 6+2 hrs means 8 hrs
- 8 x 1.5=12 units
- 12 x 13 = Rs. 156 daily
- Total 300 days we will get sunshine because we r in tropical zone
- 300 x 156 = Rs. 46800
- Now 143250/46800 = 3.2 years
- Reliability of solar is 15 - 20 years
- Hence after 4 years we will get profit
- Thus this recommends use of solar
- If Rs. 5.50 for unit thus payback period is 7 years
- 13 years of profit
- If Rs. 3.50 for unit payback period is 9.6 years
- 10 years profit

## CONCLUSION:

In this paper we designed a solar system which can be used in irrigation purpose for farmers in today's scenario with high power cuts and less rainfall. We Installed a 1.5 KW solar system and found the cost benefits for the installed model of solar plant. Calculated the payback period for the system employed in place of traditional system. We did the fault analysis for the system we designed and installed.

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