Design and Modeling of Photovoltaic Water Pumping System

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Abstract- **This paper presents an effort is made to show the effectiveness of PV solar pump in place of a conventional electric pump in industry. Solar photovoltaic systems performance depends on several environmental parameters like solar insolation, temperature, wind speed and shading. This work focuses on a Matlab/SIMULINK model of 60W photovoltaic panel. In addition, this study outlines the working principle of PV module as well as PV array. This model is based on mathematical equations and is described through an equivalent circuit including a photocurrent source, a diode, a series resistor and a shunt resistor. The developed model allows the prediction of PV cell behaviour under different physical and environmental parameters.**

Key words: PV solar pump, solar insolation

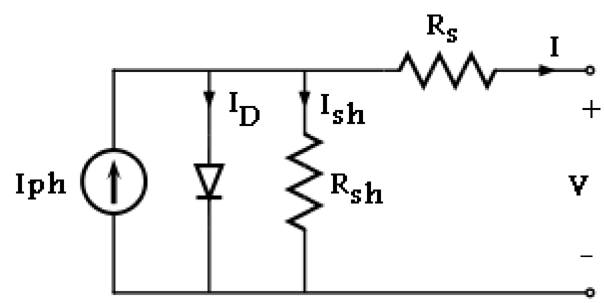
I. INTRODUCTION

With steep increase in the demand, the shortage of energy has become global problem. With seemingly poor trend of capacity increase, the burden of importing energy is increasing particularly for India in the south Asian countries. Now it has become essential to opt for alternative sources of energy. Use of solar energy in all the sectors is one of the feasible options. Electric pumps can be conveniently replaced by solar PV pumps. The initiative needs very less investment and will power. In this paper, an effort is made to show the effectiveness of PV solar pump in place of a conventional electric pump in industry.Energy in general and electrical energy in particular is not only at the center of sustainable development, but also at the center of development itself. Energy is critical for sustainable development because it is not only necessary for economic development, but also because this necessity drives societies towards environmentally unsound energy use and could severely compromise the planet itself. Solar energy is the most abundant source of energy. Suffice to say that one hour of solar energy that hits the surface of the planet is equivalent to an entire year of electric energy consumed by the entire world. PV pumping system can be used to provide regular water supply in remote areas as the electricity supply is frequently not available.Solar panels (also called Photovoltaic or PV panels) are used to generate electricity from sunlight. The electricity can be used to power a water pump, normally used for village water supply, livestock watering and small-scale crop irrigation, e.g. vegetable plants in a home garden. The water is pumped from underground into a tank, which must be large enough to store sufficient water to supply the village needs during cloudy weather. Installing a solar powered water pump is a fairly expensive option, although the systems last for a long time and are reliable.

Matlab coding hasbeen done to find the maximum power output, P_m, and voltage at maximum power output, V_m,of solar module. The annual energy yield of 60W PV module has been estimated.The model can also be used to extract the physical parameters for a given solar PV cell as afunction of temperature and solar radiation. Effect of two environmental parameters oftemperature and irradiance variations could be observed from simulated characteristics Themodel simulation results are compared with the datasheet information and they found to havegood agreement.

II. PROBLEM FORMULATION

Two MPPT algorithms, subsystems and control methods will be modeled and simulated using Matlab and Simulink with actual irradiance data. Simulation results will be presented in terms of performance parameters such as total energy produced and total volume of water pumped per day. The results further validate that MPPT can significantly improve efficiency and performance of PV water pumping system compared to the system without MPPT.



Band gap energy can be expressed as

$$E_g = E_{go}-(\alpha\times T^2)/(T+\beta) \times q \quad (1)$$

Photocurrent can be expressed as

$I_{ph}=[(I_{scr}+k_i(T+T_{refk}))](s/100)$ (2)

The saturation current of the solar photovoltaic cell can be expressed as

$I_{rs}=I_{rr}(T/T_{refk})3exp(q.E_g(1/T_{refk}-1/T)/(K.A)))$ (3)

The output current of the solar photovoltaic cell can be expressed as

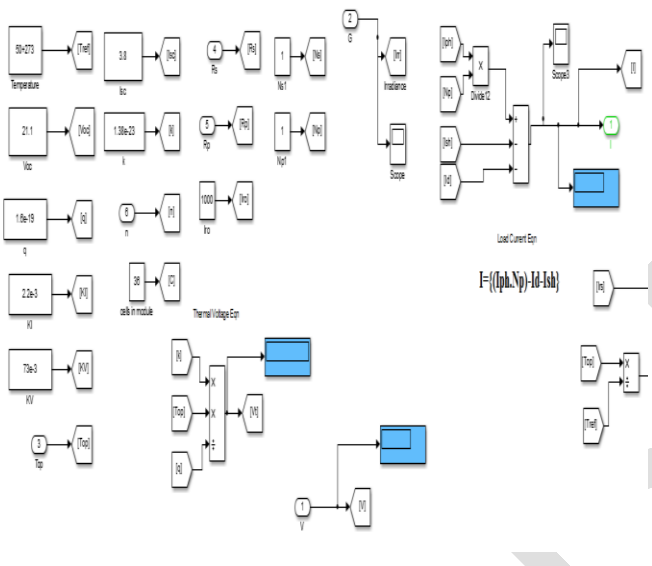
$I_o=N_p\times I_{ph}\pm N_p\times I_{rs}\times (exp(q/(k\times T\times A)\times V_o./N_s)-1)$ (4)

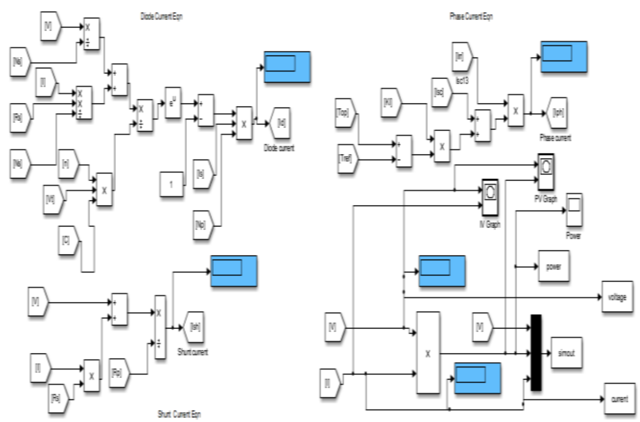
The output power is the product of output voltage and current and is expressed as $P_o = V_o\times I_o$ (5)

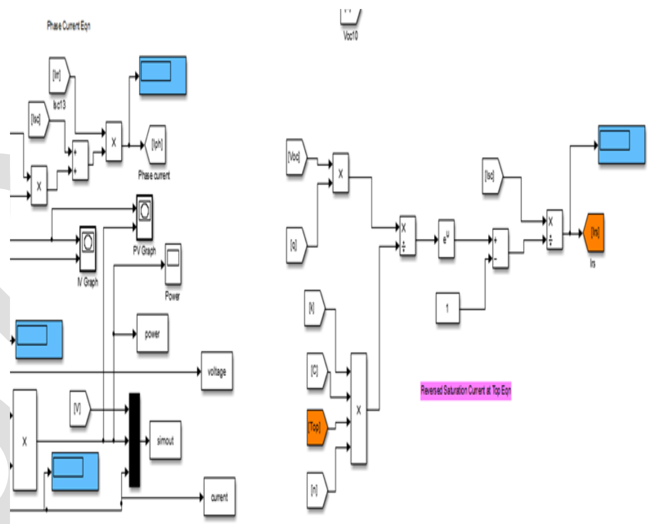
Maximum powercan be expressed as

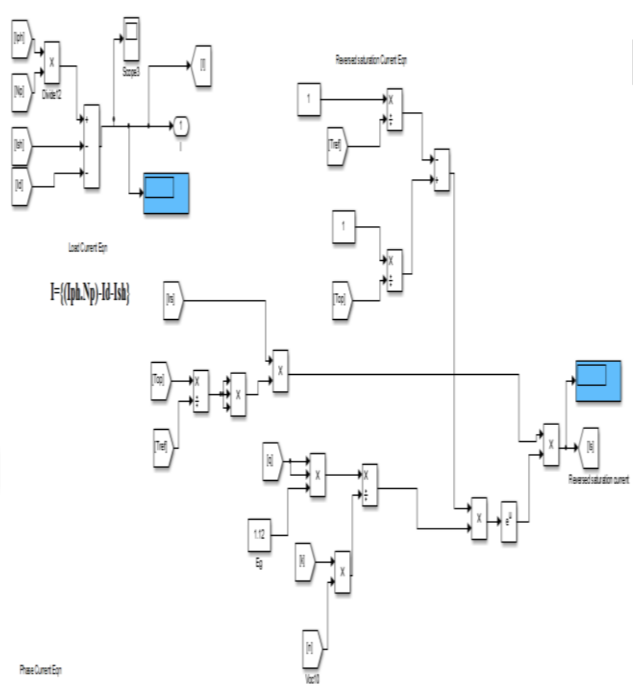
$P_{max}=V_{max}\times I_{max}$ (6)

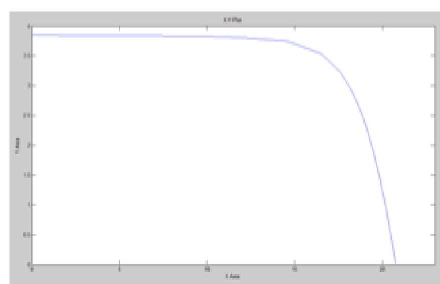
III. SIMULINK MODEL OF PV PANEL



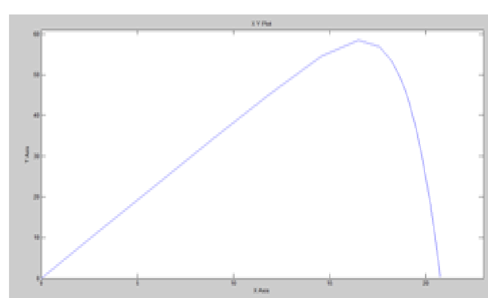






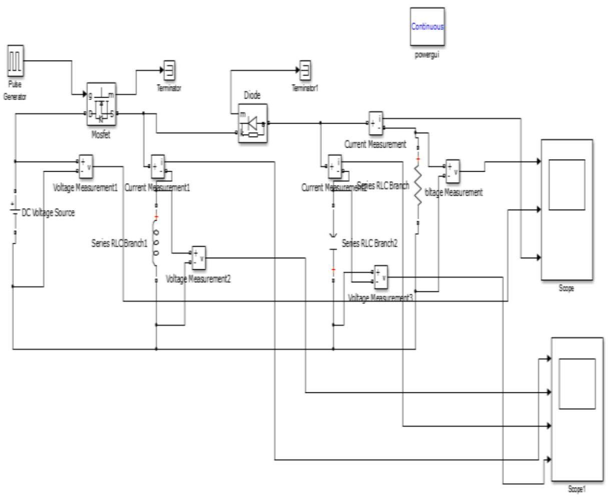


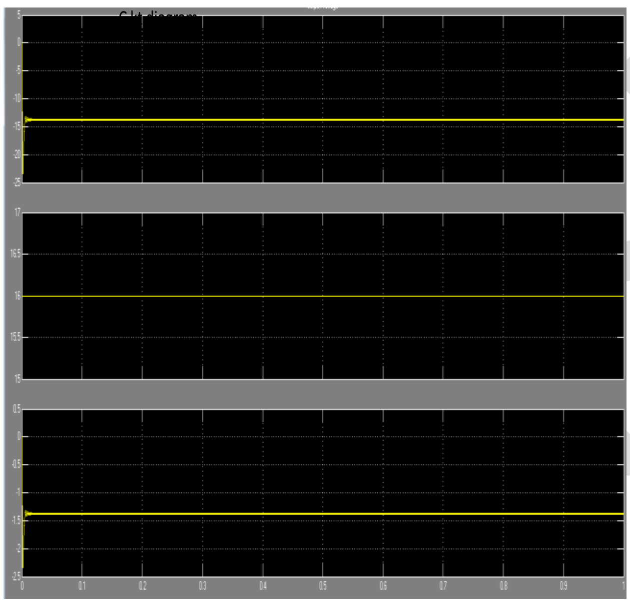
IV graph

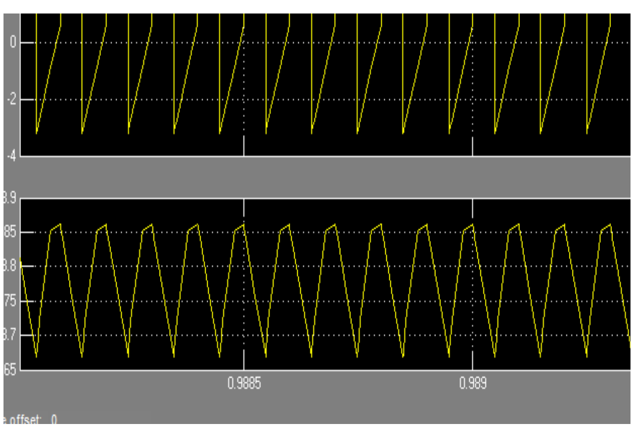


PV graph

IV. SIMULINK OF BUCK-BOOST CONVERTER







Graph of Inductor current , voltage & Capacitor current, voltage

Comparison of Dual Pump System
Conventional energy v/s Solar energy

Sr.No.	Factors of performance for comparison.	Calculations for the span of 25 years	
		Conventional Submersible Pump	Solar energy based Submersible pump
1	Life	10	25
2	Capital Cost	50227.00	225000.00
3	Operational Cost		
	1. Energy Charges		
	a)Conventional energy based Submersible Pump @ 600/- month	180000.00	
	b).Solar energy Based submersible pump		0.00
	2. Maintenance.		
	a) Conventional energy based Submersible Pump		
	Preventive Maintenance @1000.00 per year	250000.00	
	Major Repairs and Overhauling / Replacement of pump after 10 years @ Rs 22000.00	33000.00	
	b). Solar energy Based submersible pump		
	Preventive Maintenance @ Rs 50.00 per month. Cleaning of panels.		15000.00
	Major repairs and overhauling		0.00
	Total	288277.00	240000.00
	Saving	0.00	48277.00
	After 25 years of performance saving due to Solar Energy Based Submersible pump is Rs-		48277.000

V. CONCLUSION

Design aspects and modelling of PV pumping system have been depicted in detail ib the paper. Renewable energy sector growth in India during the last four years has been significant, even for electricity generation from renewable sources. In the view of rampant energy scarcity, there is need to increase the use of renewable energy sources for sustainable energy development. The Central Government or governmental agencies can mainly act as a catalyst and facilitator, with implementation being carried out by the States or by the private sector. Solar pump is a good solution to reduce the demand supply gap and can be used in remote areas.

REFERENCES

[1] Narayana, P.B.; Reddy, B.R.S.; Motepalli, P.; Dubey, S., "Design & simulation of solar DC pump in simulink," *Energy Efficient Technologies for Sustainability (ICEETS), 2013 International Conference on* , vol., no., pp.429,431, 10-12 April 2013

[2] Kappali, M.; Uday Kumar, R.Y., "An approach to reduce the size and cost of PV panel in solar water pumping," *Industrial and Information Systems (ICIIS), 2010 International Conference on* , vol., no., pp.608,613, July 29 2010-Aug. 1 2010 doi: 10.1109/ICIINFS.2010.5578633

[3] Surendra, T. S.; Subbaraman, S. V V, "Solar PV water pumping comes of age in India," *Photovoltaic Specialists Conference, 2002. Conference Record of the Twenty-Ninth IEEE* , vol., no., pp.1485,1488, 19-24 May 2002 doi: 10.1109/PVSC.2002.1190891

[4] Shrestha, J.N., "Solar PV water pumping system for rural development in Nepal: problems and prospects," *Energy Conversion Engineering Conference, 1996. IECEC 96., Proceedings of the 31st Intersociety* , vol.3, no., pp.1657,1662 vol.3, 11-16 Aug 1996, doi: 10.1109/IECEC.1996.553350

[5] Yousuf, N.B.; Salim, K.M.; Haider, R.; Alam, M.R.; Zia, F.B., "Development of a three phase induction motor controller for solar powered water pump," *Developments in Renewable*

Energy Technology (ICDRET), 2012 2nd International Conference on the , vol., no., pp.1,5, 5-7 Jan. 2012

[6] Kappali, M.; Uday Kumar, R.Y., "An approach to reduce the size and cost of PV panel in solar water pumping," *Industrial and Information Systems (ICIIS), 2010 International Conference on* , vol., no., pp.608,613, July 29 2010-Aug. 1 2010 doi: 10.1109/ICIINFS.2010.5578633