

# Vector Control Of Water Pumps Using Hybrid Renewable Energy System

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**Abstract - In this paper, the main concept of VECTOR CONTROL OF WATER PUMPS USING HYBRID RENEWABLE ENERGY SYSTEM which can be made efficient water pumping system based on photovoltaic (PV). The efficient means of water pumping through augmentation of thermoelectric conversion to increase overall efficiency of PV array and using vector control induction motor drive for pump operation. The effectiveness and feasibility of this approach is shown by simulation result. Extensive results are presented based on MATLAB/ SIMULINK.**

**Keywords - Solar photovoltaic, Hybrid renewable, Water pumping system, Thermoelectric generation system, Vector Controller of Induction**

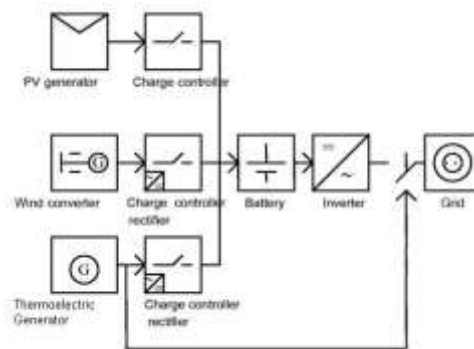
## INTRODUCTION

Lack of electricity is one of the main hurdles in the development of rural India. India's grid system is considerably under developed. The water demand has been increased due to increase in population and the availability of water have become more crucial than even before. A source of energy to pump water is also a big problem of developing countries like India. If we need to support water beyond the reach of power lines, than solar power can solve the problem.

Water pumping has a history dating back to the earliest civilizations and many methods have been developed over the years to realize this task with minimum of effort. Various power source including human energy, animal power, wind and hydro power, electrical (grid) power and fossil fuel power generator/ pump pumping sets have been utilized to accomplish this.

Moreover, in the isolated sectors as the islands and the rural zones, the use of the renewable energy such as photovoltaic and PV battery based hybrid systems are better solution to produce the needed electric energy for such applications as power system. A hybrid energy system or hybrid power, usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply. To entrains the pump through control action of motors by developing new efficient and flexible modes, this can be done by considering the solar energy fluctuation and solar energy optimizing necessities. Photovoltaic-battery hybrid system feeds the vector control of an induction motor, this vector control is discussed in this paper.

By using vector control (also called Field oriented control) induction motor drive for pump operation the motor is started at low frequency decided by controller and finally runs at the steady state condition at the set reference value of speed thus reducing the initial inrush current load on the solar panel. Fast response of vector control makes it better than other method of speed control of induction motor. With the help of vector controller we attend maximum response in minimum time.



**Fig. 1.1** Schematic principle of a hybrid system with PV, wind, and Thermoelectric generators

**Hybrid Systems:** This system are the combinations between different technologies to produce power. In power engineering, the term 'hybrid' describes a combined power and energy storage system. Hybrid power plants often contain a renewable energy component (such as PV) that is balanced via a second form of generation or storage such as a diesel genset, fuel cell or battery storage system. They can also provide other forms of power such as heat for some applications.

In 2015, a case study conducted in seven countries concluded that in all cases generating costs can be reduced by hybridizing mini-grids and isolated grids. However, financing costs for diesel-powered electricity grids with solar photovoltaic are crucial and largely depend on the ownership structure of the power plant. While cost reductions for state-owned utilities can be significant, the study also identified short-term economic benefits to be insignificant or even negative for non-public utilities, such as independent power producers.

**Solar Water Pump:** Solar PV water pumping systems are used for irrigation and drinking water in India. The majority of the pumps fitted with a 2000watt-3700watt motor that receives energy from a 4800Wp PV array. By 30 August 2016, a total of 1,20,000 solar PV water pumping systems have been installed in India.



**Fig. 1.3** Example of water pumping with PV

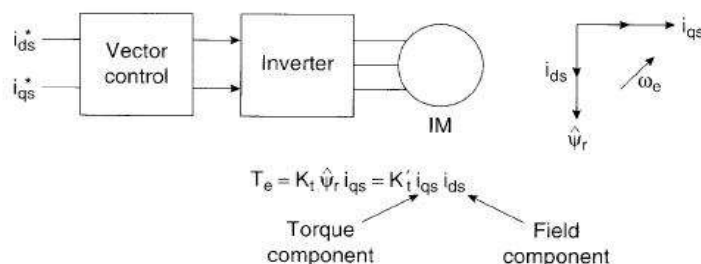
A solar-powered pump is a pump running on electricity generated by photovoltaic panels or the radiated thermal energy available from collected sunlight as oppose to grid electricity or diesel run water pumps. The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance costs and has less environmental impact than pumps powered by an internal combustion engine (ICE). Solar pumps are useful where grid electricity is unavailable and alternative sources (in particular wind) do not provide sufficient energy.

**Thermoelectric Generator:** A thermoelectric generator (TEG), also called a Seebeck generator, is a solid state device that convert heat flux( temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect). Thermoelectric generators function like heat engines, but are less bulky and have no moving parts. However, TEGs are typically more expensive and less efficient.

**Thermoelectric Generators:** Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power. PV alone amidst thermal insolation does not confirm to efficient way of energy conversion and certainly needs good heat sinks to operate efficiently throughout the duration of solar insolation. Hybridization of PV with thermoelectric modules can increase the overall efficiency of the solar energy conversion system by keeping the temperature constant within limits thus overcoming the detrimental effects of changing temperature on PV cell.

**Vector Control :** Vector Control is used to drive the AC motor. This control is done with only two direct measures: two phase input currents. Use of standard asynchronous motors presents lower costs than other commercial systems. The PV array is arranged to cover the possible applications of the Power Conditioner: Pumping, Isolated Home and Multi-point generation. The inverter's tasks are the following:

1. Extracting the maximum power from the PV array
2. Feeding the load; controlling flux and speed of the AC machine.



**Fig 1.4:** Vector controlled induction motor

**MPPT:** Maximum Power Point Tracking is an algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called maximum power point (peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

The major principle of MPPT is to extract the maximum available power from PV module by making them operate at the most efficient voltage (maximum power point). That is to say: MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best power that PV module can produce to charge the battery and convert it to the best voltage to get maximum current into battery.

MPPT is a DC to DC converter which operates by taking DC input from PV module, changing it to AC and converting it to back to a different DC voltage and current to exactly match the PV module to the battery.

**MATLAB:** It deals with modeling of various components like, PV array, TEG and vector control of AC motor for pump applications. The dynamic model of the system components are developed in MATLAB/ SIMULINK and are simulated under dynamic loading conditions as well as simulated under MATLAB environment for operation of vector control induction motor drive. Model of hybrid combination of thermoelectric- PV array have been developed and simulated. The system performance is also observed under these conditions. Matlab/Simulink model is proposed for studying the behaviors of these machines with respect to water flow capacity, motor current, electro-magnetic torque, and motor efficiency. Matlab / Simulink for proposed mathematical model is presented for vector control induction motor pump, taking into account that varying the motor voltage and frequency. The performance of the PV array has been evaluated through simulated in Matlab/Simulink environment for the dynamic variations in solar insolation and connected load. The simulation model have been developed in MATLAB environment along with simulink and power system block set toolbox.

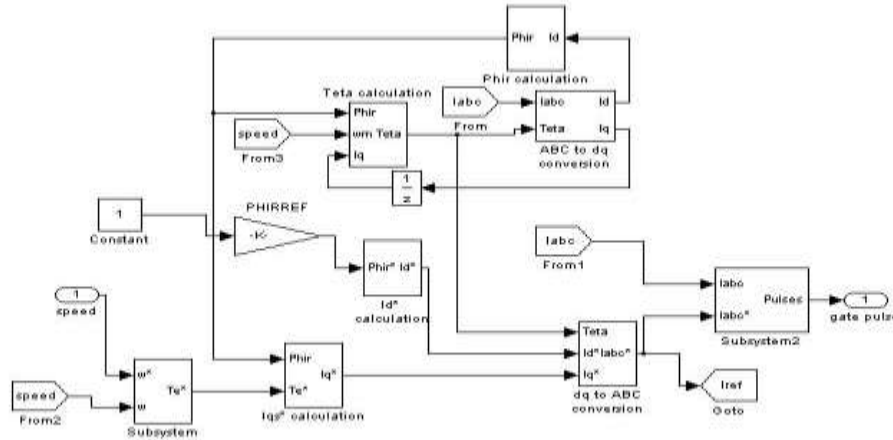


Fig 1.5: Vector Controller designed in Matlab/Simulink for Pump/motor

### Future Research

Cost analysis and payback period method for both systems (Hybrid & non Hybrid) in order to see which one is more preferable. Large scale experiments, as well as experiments in a more controlled environment to determine which of the many physical processes involved has the greatest influence on the optimization of the systems. Investigation in the quality of the electricity and heat produced by both systems Implementation of both systems in real life conditions and monitoring of their performance. Determination of the impact of the stack effect(Hybridizing) on the system.

### CONCLUSION

The performance of the water pumps connected to the photovoltaic systems both during steady state operation has been investigated and demonstrated through MATLAB simulations. The efficient way of using this heat is by using thermoelectric conversion modules. The presented simulation results reveal the effectiveness of the proposed hybrid technique. Photovoltaic systems must be operated near the maximum power point to extract maximum energy from the system. The heat produced by direct sunlight decreases the overall efficiency of the photovoltaic system. By using vector control induction motor drive for pump operation the motor is started at low frequency decided by the controller and finally runs at the steady state condition at the set reference value of speed thus reducing the initial inrush current load on the solar panel. The main objective of the work has been to model a PV, TE and hybrid PV-TE water pumping system using solar power. The work has been carried out for modeling of solar energy conversion system employing photovoltaic and thermoelectric cells as basic unit for the conversion system. The simulation of pumping system with vector control of pump/ motor powered by photovoltaic has been successfully demonstrated.

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