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Induction Motor Performance Analysis Based On Residential Photovoltaic Water Pumping

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ABSTRACT: Performances of induction–motor-based residential photovoltaic water pump system (IMRPWPS) with low DC voltage input (24V DC) are tested in laboratory under four different operation modes, such as efficiency of DC-AC converter with high-frequency DC-DC stage machin epump and overall system. By analysis of these experiment results, it is discovered that the operation head and voltage frequency ratio of motor (U/f) have significant effect on the performances of IMRPWPS besides the configuration of system components. And the minimum unit water cost may not be reached only by the control strategy of maximum output power of the system. Hence, as for a certain site, the proper selection of characteristics of converter and motorpump and optimal ratio of U/f is significantly important to improve the economic performance of the system.

KEYWORDS: PV cell, induction motor, Flow Sensor, Audino UNO , IC 4047 , Step-up transformer

I.INTRODUCTION

Photovoltaic water pumping systems (PVWPS) are now increasingly demanded in rural districts. PVWPS in practical use now are mostly based on DC motors or DC brushless permanent motors [1]. These motors are specially designed to operate at low DC voltage (say, 24 VDC, 36V DC) from solar array. If the well is deeper, the wire cable that connects motor and controller should be longer too. In that case, great voltage and efficiency drop will be caused. In addition to , DC motors or DC brushless permanent motors above are complicated in manufacture and more expensive. In contrast, regular asynchronous induction motors (RAIM) are much cheaper and easier to manufacture in large quantity. So, for most developing countries, RAIMs may be more economic choice. But RAIMs cannot be used in photovoltaic system directly because they need 380 /220 AC voltage supply. To bridge the gap, a frequency-variable driving power supply (FVDPS) has been developed for the induction–motor-based residential photovoltaic water pump system (IMRPWPS) with low input DC voltage and regular induction motor by authors' group. This paper is aimed at investigating the relationship between system efficiency, unit volume water cost and power size and control strategies by simulation and test in Lab to conclude some important rules to design a higher efficiency IMRPWPS.

Solar energy is the most low cost, competition free, universal source of energy as sun shines throughout. This energy can be converted into useful electrical energy using photovoltaic throughout. This energy can be converted into useful electrical energy using photovoltaic technology. The steady state reduction of price per peak watt and simplicity with which the installed power can be increased by adding panels are attractive features of PV technology Among the many applications of PV energy, pumping is the most promising. In a PV pump storage system, solar energy is stored, when sunlight is available as potential energy in water reservoir and consumed according to demand. There are advantages in avoiding the use of large banks of lead acid batteries, which are heavy and expensive and have one fifth of the lifetime of a PV panel. A number of experimental DC motor driven PV pumps are already in use in several parts of the world, but they suffer from maintenance problems due to the presence of the commutator and brushes. Hence a pumping system based on an induction motor can be an attractive proposal where reliability and maintenance-free operations with less cost are important. The effective operation of Induction motor is based on the choice of suitable converter-inverter system that is fed to Induction Motor. Photovoltaic technology is one of the most promising for distributed low-power electrical generation.

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II. SYSTEM MODEL DESCRIPTION

1) Simulation Model Of Three Phase

This is simulation model of three phase . In this model each solar array is 80v. This solar array gives input to the IGBT inverter .This IGBTI inverter is used for the covertion purpose DC-AC this inverter is designed for three phase model. V-I measurement used for the phase to phase connection . Delta-Delta transformer carry large current on low voltage and maintained the continuity of service even through one of the phase develope fault. Voltage measurement block used for measuring the instantious voltage. In this model three phase induction motor is used this is 400v .

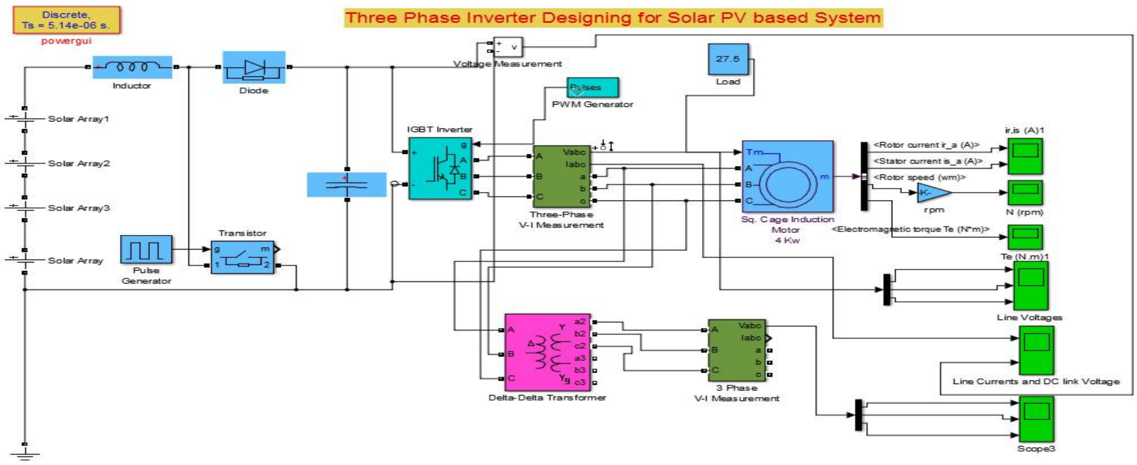

Figure 1 Three phase inverter designed for solar PV based system

PWM is pulse width modulation . this PWM generator gives input to the IGBT inverter. In this model also inductor, diode , capacitor and transistor is used . The function of transistor as amplification of electric signal transistor is semiconductor device pulse generator give input to the transistor . A diode is can allow the electric current to flow in one direction only.The diode perform the work of allowing the current to pass only in the forword direction and not in reverse direction .The unidirectional property of the diode is used in rectification of alternating current and in modulation and demodulation .Inductor is used for the purpose filters to separate signals of different frequeny. Capacitor is store the current and this current give the circuit when it necessary.

2) Simulation Model Of Single Phase

This is single phase simulation model. This is same working like previous model .In this model single phase motor used it is 220v and inverter is designed for single phase

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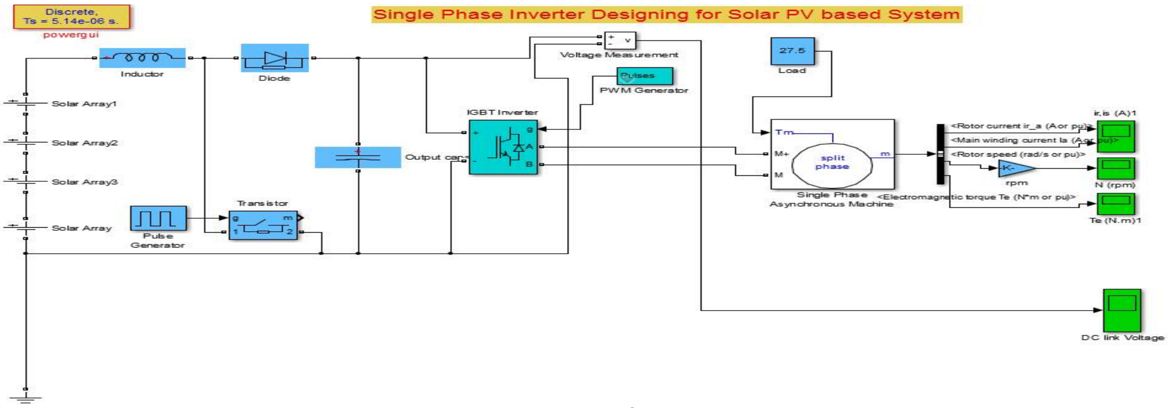

Figure 2 Single phase inverter designed for solar PV based system

3) Hardware Model Of Single Phase

This is hardware model working of this model show the following diagrame.

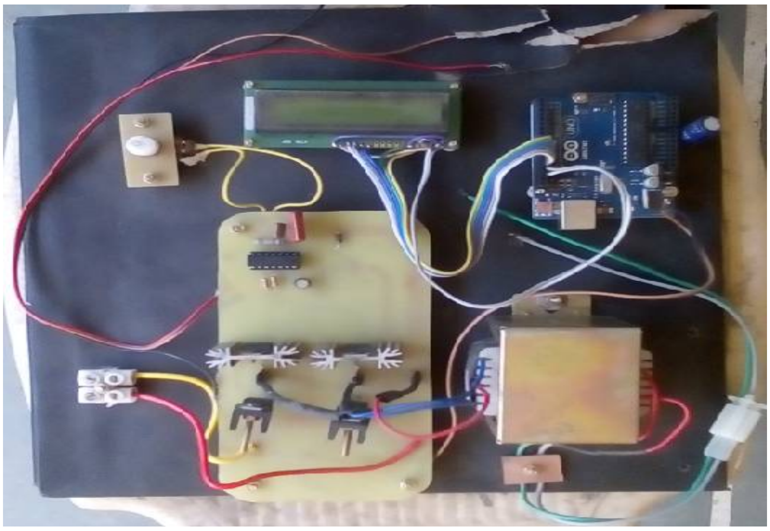

Figure 3 Hardware model of single phase

PV panel give supply to the IC 4047.In this model IC 4047 is used as a free running multivibrator, oscillator . This IC is suitable for all type of inverter, converter and timer application. This IC gives 12v supply to the step up transformer. Core type step-up transformer is used. This transformer is used for starting of a motor. Secondary winding is greater than the primary winding . Input of this transformer is 12v and output is 220v. IC 4047 gives input to the Step-up transformer that is 12v. This transformer gives input to the motor and then it run.
PV panel it is used for the hardware model it is 20w , 20v and current is 2.5 amp.

Motor and flow sensor

Motor it also used for hardware model it is 20w and 220v. Hall Effect water flow sensor is used as a sensing unit with a turbine rotor inside it whose speed of rotation changes with the different rate of flow of water. The Hall Effect sensor outputs the corresponding pulse train for frequency input to the microcontroller. The whole system comprises of

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AT89S52 microcontroller, G1/2 Hall Effect water flow sensor, relay, optocoupler, a water pump, 5V supply, LCD, keypad and some passive components.

III. PERFORMANCE RESULTS AND ANALYSIS

Simulation Result Of Three Phase

Waveform of three phase stator and rotor current

When voltage of solar array change then stator and rotor current also change . Following waveform show the stator and rotor current. From this fig it is show that starting current is high and then it constant.

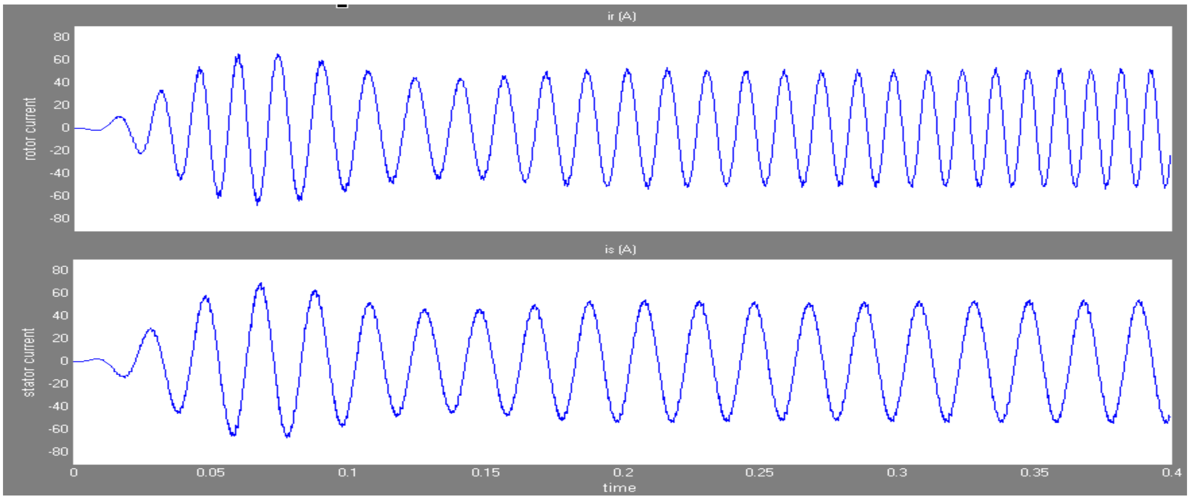

Figure 4 Waveform of three phase stator and rotor current

Waveform of three phase DC link voltage

When frequency change then DC link voltage also change .Following waveform show the l DC link voltage. Starting DC link voltage is high as compare to single phase.

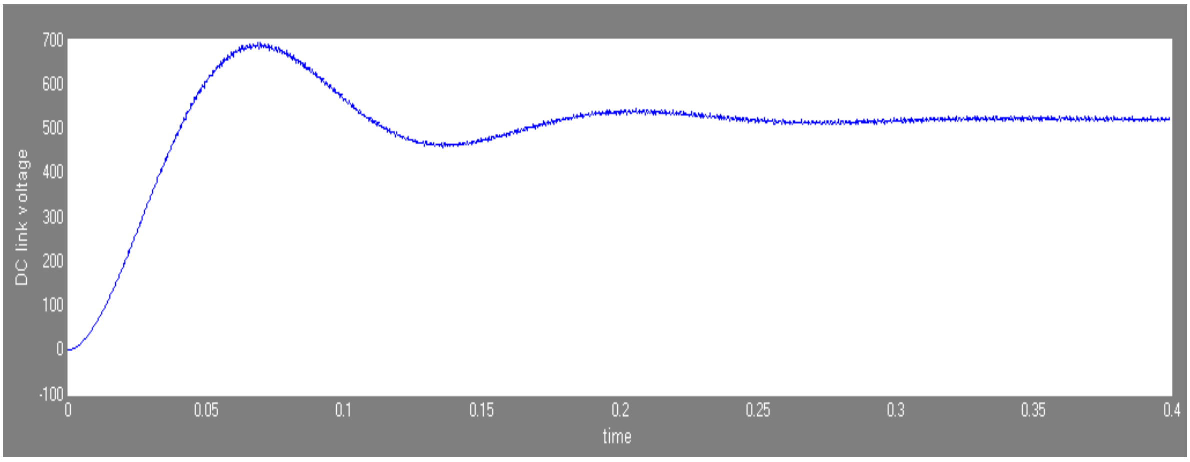

Figure 5 waveform of three phase DC link voltage

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Simulation Result Of Single Phase

Waveform of single phase stator and rotor current

When voltage of solar array change then stator and rotor current also change . Following waveform show the stator and rotor current. From this fig it is show that starting current of rotor current is low and it is not a constant form but statcurrent is high as compared to rotor current and it also constant form.

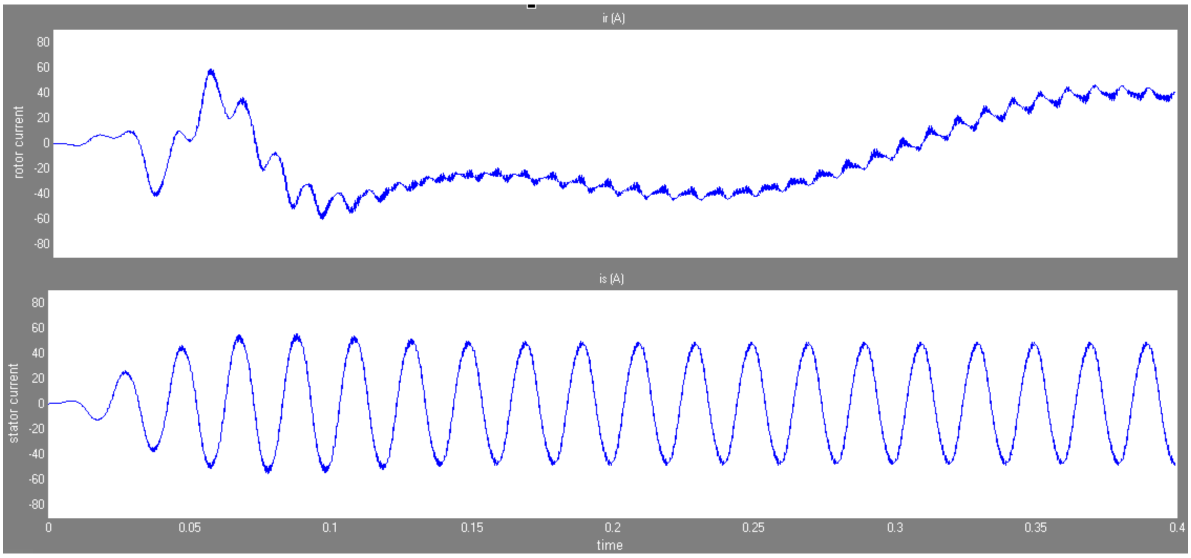

Figure 6 Waveform of single phase stator and rotor current

Waveform of single phase DC link voltage

This is DC link voltage of single phase .This waveform is pulsating. Starting DC link voltage is low as compare to three phase model.

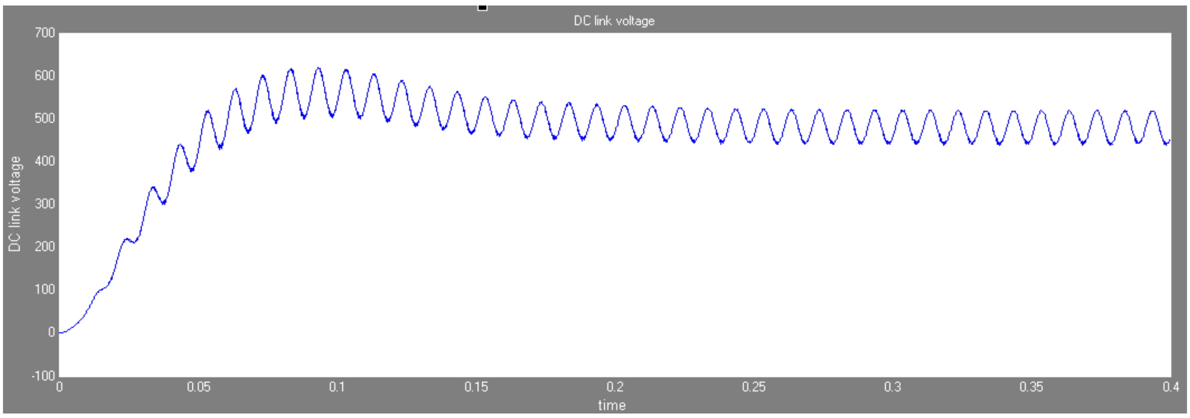

Figure 7 Waveform of single phase DC link voltage

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Hardware Results Of Single Phase

Output at oscillator stage

This is result of hardware model and it's a waveform of output at oscillator stage.

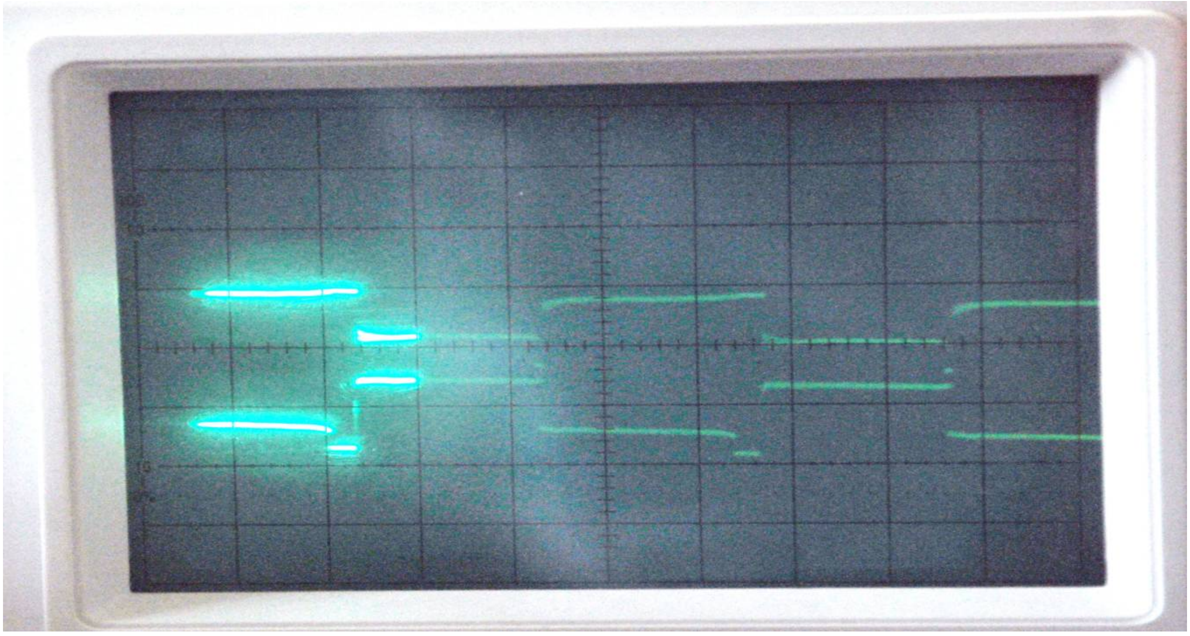

Figure 8 Output at oscillator stage

Output from transformer

This is waveform of output of transformer.

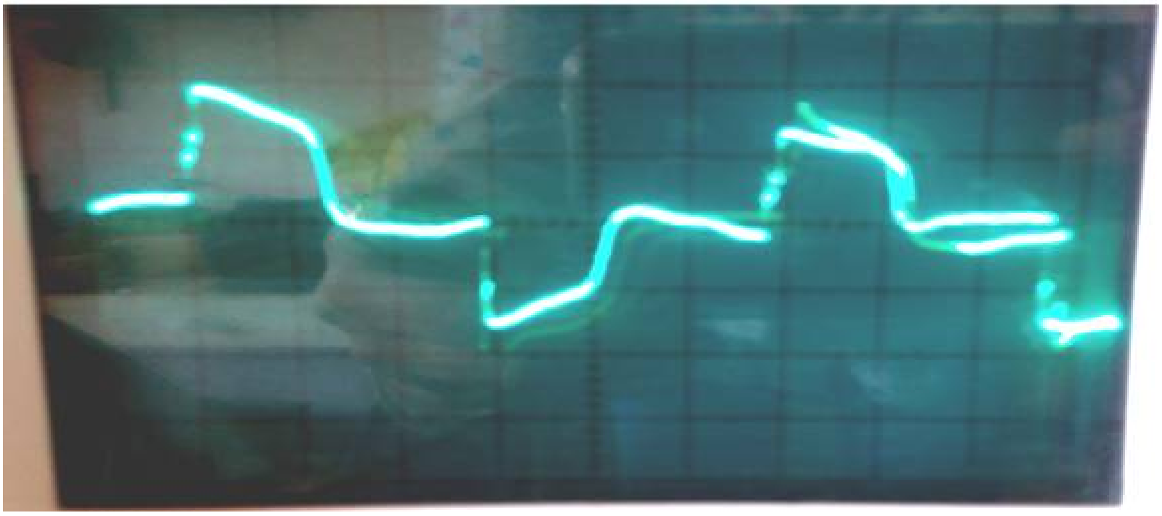

Figure 9 Output from transformer

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A different result of hardware model

Table 1 Different result of hardware model

Sr. No.	Time	Solar output (V)	Transformer output (V)	Motor Flow Output(ml/s)	Frequency (Hz)
1	11.50 am	18.53	237.3	185	48.2
2	12.20 pm	18.70	252.4	193	48.51
3	1 pm	19	270.1	231	48.80
4	1.35 pm	19.20	286	251	50
5	2 pm	19.01	275.2	240	49
6	2.30 pm	18.30	225.1	169	48
7	3 pm	18	218	162	48

IV. RELATED WORK

1. João Victor M (1) proposes a new converter for photovoltaic water pumping and treatment systems without the use of storage elements. The converter is designed to drive a three-phase induction motor directly from PV solar energy. The use of this motor has the objective of presenting a better solution to the standard DC motor water pumping system. The development is oriented to achieve a commercially viable solution and a market friendly product. The converter topology is based on a Resonant Two Inductor Boost converter and a Three-phase Voltage Source inverter achieving 90% efficiency at a rated power of 210W. The total cost of the proposed converter is below US$ 91.00 and the system is expected to have high lifetime, due to the inexistence of electrolytic capacitors.
2. P Sadasivam (2) proposes Photovoltaic powered pumps are becoming popular. Their operation differs from that of the AC Mains powered pump, as they work under varying input power conditions. The efficiency figures of different subsystems will keep changing due to varying solar radiation conditions, causing the variations in overall efficiency under partial load operating conditions of the pump. The aim of this work is to study the performance of the various subsystems under these operating conditions. The system developed here consists of a Photovoltaic (PV) array of 900 Wp with 72 V nominal DC bus, a DC to DC Converter, a Variable Frequency Drive (VFD) and a three phase induction motor driven submersible pump. Maximum Power Point Tracking (MPPT) algorithm has been developed and implemented to maximize the use of PV power generated at any given instant.

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V. CONCLUSIONS

From experiment results and analysis above, the conclusions can be reached as follows:

- The optimization of ratio U/f will also improve the performance of the system.
- This provided a review on the factors that influence the performance and efficiency of a solar water pumping system.
- At a certain input DC power, the change of head and flow will not give rise to remarkable fluctuation of motor pump efficiency. This proves dynamic optimal operation control of head may improve the whole system efficiency greatly.
- AC induction motors are more energy efficient than DC motors.
- The system is economically feasible in interior areas where no electricity or it is an alternate source of electricity.

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