Performance Analysis of Solar based Induction Motor for Water Pumping System

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Abstract— Performance analysis of solar photovoltaic array fed single phase induction motor (IM) drive for water pumping system. In the proposed method, the output DC power of the solar PV array is stored in battery and the stored DC energy is directly fed as input to the inverter and output of the inverter is fed to the single phase induction motor for water pumping system. A centrifugal pump connected with the single phase induction motor for water pumping system. The size of PV array and motor rating selected such that the water can also be pumped during the varying in temperature and irradiation level. This study evaluates the performance parameters namely current, speed, temperature and vibrations. The GUI is developed to control the action of motor and monitor the above mentioned parameters values through appropriate sensors and microcontroller. The speed control through microcontroller by varying the pulse ON duration is studied as well as the effect of speed on vibrations is also observed. The critical experimentation is carried out to analyze the above said parameters and examines the effectiveness the single phase induction motor for solar PV based water pumping system.

Keywords— Solar, Induction motor, microcontroller, vibration sensor, irrigation, temperature, speed, GUI, etc.

I. INTRODUCTION

Solar energy is the lowest cost, competition free, universal source of energy as sun shines 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. Converters like Buck, Boost and Buck-Boost converters are popularly used for photovoltaic systems. But these converters are limited to low power applications. For PV applications like pumping these converters could do a good job as pumping is carried out at high power. Thus a new push pull converter which is two switch topology can do justice by giving a high power throughout. The Induction Motors are the AC motors and hence from converter, an inverter system is also required to obtain an AC voltage. This inverter is chosen based on its advantages and it is fed to induction motor. Photovoltaic technology is one of the most promising for distributed low-power electrical generation. The steady reduction of price per peak watt over recent years and the simplicity with which the installed power can be increased by adding panels are some of its attractive features. Among the many applications of photovoltaic energy, pumping is one of the most promising. In a photovoltaic pump-storage system, solar energy is stored, Water pumping is one of the simplest and most appropriate uses for photovoltaic.

From crop irrigation to stock watering to domestic uses, photovoltaic-powered pumping systems meet a broad range of water needs. Most of these systems have the added advantage of storing water for use when the sun is not shining, eliminating the need for batteries, enhancing simplicity and reducing overall system costs. Many people considering installing a solar water pumping system are put off by the expense. Viewing the expense over a period of 10 years, however, gives a better idea of the actual cost. By comparing installation costs (including labor), fuel costs, and maintenance costs over 10 years, you may find that solar is an economical choice. A solar-powered pumping system is
generally in the same price range as a new windmill but tends to be more reliable and require less maintenance. A solar-powered pumping system generally costs more initially than a gas, diesel, or propane-powered generator but again requires far less maintenance and labor.

II. PROPOSED METHODOLOGY

The proposed methodology for the project is presented in this section and Fig. 1 shows the block diagram for the proposed methodology. The solar radiation are incident on the solar panel which are converted to the DC energy and stored in the battery of the specified ratings as per the requirement. The DC voltage from battery is then fed to the inverter which converts DC to AC supply required to run the Induction Motor. The AC supply is fed to IM through relay driver circuit utilizing three relays which sequentially turns ON and OFF with predetermined ON and OFF time duration to achieve the desired speed of rotation. The ON and OFF time of the relays are controlled from the program written in .NET framework and the hardware is controlled through relay drivers from the 8051 microcontroller. The communication between microcontroller and PC is done through proper signaling by serial interface IC MAX232 which is a logic level converter IC. As per the main task of the proposed work, to monitor the performance of the IM four sensors are used for this purpose namely temperature, speed, vibration and the current. All this sensors are fitted along the body of IM at appropriate places to collect the proper readings of the required parameter. This sensors are interfaced to microcontroller though Analog to digital converter IC which converts the incoming analog quantity to proportional digital quantity to be fed to the microcontroller. All the readings of the said parameters are taken with respect to time and corresponding values are stored in the log file in PC. All this values are used for the analysis of the system.

III. EXPERIMENTAL RESULTS

For controlling and monitoring the behavior of the system the Application is developed in .NET framework and GUI is shown which allows controlling various actions and observing the readings from sensors. Fig. 2 shows the first appearance of GUI at the time of starting of application. The GUI form shows the parameters of the motor when the pulse T1 is triggered for speed 1, as shown in fig. 3. Similarly, for speed 2 and speed 3, pulse T2 and T3 can be triggered from the GUI.
Various experimentation is done to analyze the performance of the IM powered by solar energy through inverter and triggering circuit. The main focus of experimentation is to test following parameters of IM based water pump namely Vibration, temperature, speed and current with respect to time without and with load.

Here, first the tests are performed for speed 1 = 90rpm without load. For this speed the readings from current, temperature and vibration sensors are taken and plotted to analyze the performance.

**Table 1 Variation of current vs time for speed 1=90rpm without load**

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Current (Amp.)</th>
<th>Temperature (Celsius)</th>
<th>Vibration (Hz)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2.5</td>
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12 | 1.5 | 37 | 208
13 | 1.5 | 37 | 207
14 | 1.6 | 37 | 207
15 | 1.6 | 36 | 208
16 | 1.5 | 37 | 208
17 | 1.5 | 37 | 208
18 | 1.5 | 37 | 208
19 | 1.5 | 37 | 208
20 | 1.4 | 37 | 208
21 | 1.4 | 36 | 208
22 | 1.4 | 37 | 208
23 | 1.4 | 37 | 209
24 | 1.4 | 38 | 209
25 | 1.3 | 38 | 209
26 | 1.3 | 38 | 209
27 | 1.3 | 38 | 209
28 | 1.2 | 37 | 210
29 | 1.2 | 37 | 210
30 | 1.2 | 38 | 210

Fig. 4 Graph for variation of current vs time for speed 1=90rpm without load

Fig. 5 Graph for variation of temperature vs time for speed 1=90rpm without load
The same experimentation is carried out for two more speeds i.e. speed 2 = 125rpm and speed 3 = 150rpm without load.

Now, the tests are performed for speed 1 = 90rpm with load. For this speed the readings from current, temperature and vibration sensors are taken and plotted to analyze the performance.

Table 2 Variation of current vs time for speed 1=90rpm with load

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Current (Amp.)</th>
<th>Temperature (Celsius)</th>
<th>Vibration (Hz)</th>
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</table>
The same experimentation is carried out for two more speeds i.e. speed 2 = 125rpm and speed 3 = 150rpm with load.

After this experimentation, the effect of speed of motor on the vibration needs to be studied. So, the speed has varied in terms of five variations and the corresponding readings from vibration sensor are taken. The following table 3 shows the values obtained and graph shows the nature of variation.
Table 3 Effect of speed on vibration

<table>
<thead>
<tr>
<th>Speed</th>
<th>Speed (rpm)</th>
<th>Observation Time (min)</th>
<th>Vibration (Hz)</th>
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<tbody>
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After analyzing the above table and fig., it can be concluded that the vibration of motor increases as the speed of motor increases.

![Variation in Vibration wrt Speed](image)

**Fig. 10 Effect of speed on vibration**

### IV. CONCLUSIONS

A review of current status of solar photovoltaic water pumping system technology research and applications is presented. The system is designed which utilizes the solar energy, stores it in batteries, convert it to AC supply with the help of inverter for running the single phase induction motor. The running of motor is controlled through microcontroller...
by controlling the pulses which makes the relays ON and OFF as per time specified in the program feed in through the PC. The GUI is developed to control the running of motor and to monitor the performance parameters to be analyzed which are as follows current, speed, vibration and temperature. The controlling software is developed in .NET framework. To control the speed of motor and to interface sensors microcontroller 8051 is used.

Now, the main focus of the proposed work was to analyze the performance parameters namely current, speed, vibration and temperature in both conditions of with and without load. In case of without load, it is observed that current was having higher values at the starting of motor but as the motor achieves the rated speed the current required to run the motor was decreased and remain nearly constant. The temperature of the motor is observed over the period of time and it is found that temperature increases with the time for various speeds. The amount of vibrations with respect to time is observed and it is found that the vibration also increase as the time increases. But after some time the vibration remains approximately constant.

In the case of with load condition, the nature of graphs for current, temperature and vibrations are found nearly same. The difference was found in the magnitude of parameters. In case of with load condition, the current drawn was higher than that of without load condition while the temperature and the vibrations are reduced to the considerable level as compared to the without load condition. In all, the current taken by the motor is increased whereas the temperature and vibrations are decreased, when the IM is run with load.

The experimentation is done to observe the effect of speed on vibrations by taking readings from vibration sensor for different speeds over the fixed interval of time. It is concluded that as the speed increases, the vibrations also increases. There is linear relationship between the speed and vibrations.

REFERENCES


