IJIREEICE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

NCIET- 2020

National Conference on Innovations in Engineering & Technology

Govt., Polytechnic College, Palakkad, Kerala

Vol. 8, Special Issue 1, February 2020

Simulation of A Solar Powered Water Pumping System Using Induction Motor

Unnima Unnikrishnan[1], Aneesh V A[2]

PG Scholar, Electrical and Electronics Engineering, Government Engineering College Idukki, India[1]

Assistant Professor, Electrical and Electronics Engineering, Government Engineering College Idukki, India[2]

Abstract: Sun is one of the most abundantly available sources of renewable energy, which is the major solution for future energy crisis. In this paper presents solar based water pumping system. The pump system uses two converters. One is a DC-DC boost converter and the other is a three-phase DC-AC inverter. Boost converter used to step up the voltage from PV panel also to obtain constant voltage to the inverter. VSI is used as the inverter and used to provide AC voltage to the motor section. Motor used here is a three-phase induction motor since it shows more advantages concerning of availability and cost. The installation cost of the PV is very high, so when it is installed the next step is to extract maximum power from the panel of installed capacity. Suitable MPPT method is also used. To control the speed of induction motor V/F control method is used. The detailed design and MATLAB /SIMULINK model of the system is given.

Keywords: Maximum Power Point Tracking (MPPT), Photo Voltaic (PV), Boost converter, Voltage Source Inverter (VSI), Induction motor drive, V/F control.

I. INTRODUCTION

Energy is the main inevitable input to the growth and development of a country. Among the worlds about 21\% of the people do not have adequate water available for their day today needs. Mostly in rural and remote areas water required for their needs is pumped from distant places. The availability of electricity to those areas is also a major concern. At the same time energy crisis are begun to rise all over the world. Conventional energy sources like fossil, coal and nuclear materials are going to be extinct. Usage of renewable energy sources include wind, solar, biomass, geothermal are emerged as the remedy for future energy crisis[1]. Among different renewable energy sources solar energy shows dominant. It is more suitable for water pumping systems in rural areas[2].

In earlier days PV systems have low efficiency and high cost. The efficiency in those days is around 5-6\% [3]. Then by the increased technology the efficiency now reached up to 16-17\% in other hand prices are also decreasing evenly. At present scenario solar energy utilization is considered as the most up-and-coming source of energy for future in the matter of abundant availability, environmental friendly, less pollution and reduced maintenance etc. With the advancement of technology PV systems are now in growing state and have to deal with problems with inefficiency, discontinuity and a high starting cost. Solar based water pumps are acquiring more attraction in isolated areas [4]-[5].

Solar water pumps can be blessings for farmers. Extremely low operating cost, comparatively low maintenance, simple and highly reliable; eco-friendly are the advantages. Due to the challenge such as high installation cost when the panel is installed the major aim is to extract maximum power from the panel. Several MPPT algorithms are used for this [6]. A single stage PV system with dual ended induction motor drive introduced [7]. Two ends of stator winding are connected to phase and it reduces the voltage rating of semiconductor but increased device count and complex control circuitry. Then one energy efficient standalone water pumping system is discussed [8]. It uses a permanent magnet synchronous motor instead of induction motor. Control is based on FOC method. Total overall cost is high.

[9] Introduces improved induction motor drive using frequency control. P\&O algorithm used for maximum power tracking. But overall efficiency reduces.

Effective induction motor control using additional DC-DC converters like push-pull converters [10]. Gives more setup ratio. Central tapped transformers are used which is the main disadvantage of the system. Induction motors usually used for constant speed applications. But recently they can be used for variable speed applications driven by inverters.

By controlling the applied frequency and voltage to the motor variable speed induction motor can be realized. Robustness, simplicity, wide speed range, low maintenance, low torque ripple and reduced noise, cost efficient, stabilized power and ability to operate in any environment makes the drive more reliable than other commercially available motors. To drive the induction motor

IJIREEICE
ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
NCIET- 2020
National Conference on Innovations in Engineering & Technology
Govt., Polytechnic College, Palakkad, Kerala
Vol. 8, Special Issue 1, February 2020

uses a three-phase voltage source inverter. For controlling the system different control methods including vector and scalar control is possible. Among them V/F method is more dominant. This algorithm is the basic control mode which is widely used in pump applications. Smooth starting, smooth acceleration & deceleration time, better stopping methods and reversing of motor, reduced harmonics, increased power factor and can save huge money. Solar panels can be designed in any configuration. Solar pumping systems are great way to provide water to agricultural fields. It can be used along with water treatment plants and irrigation purposes.

II. TOPOLOGY DESCRIPTION

The block diagram of the solar water pumping system given fig. 1. It is composed of solar PV array, a DC-DC converter, DC-DC converter, Induction motor, PI controller, SPWM and a centrifugal pump.

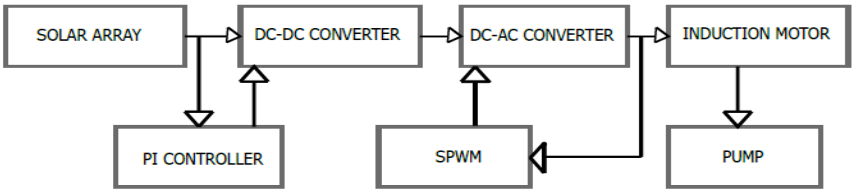

Fig. 1. Block diagram of the system

The circuit diagram is given below in fig. 2. It consists of a PV panel, a boost converter, a voltage source inverter, an induction motor drive and a pump. For tracking of maximum power MPPT algorithms uses.INC algorithm is better. The output of MPPT is fed as the switch driver for the boost converter. To convert DC to AC uses a three phase voltage source inverter. For speed control of induction motor uses V/F method.

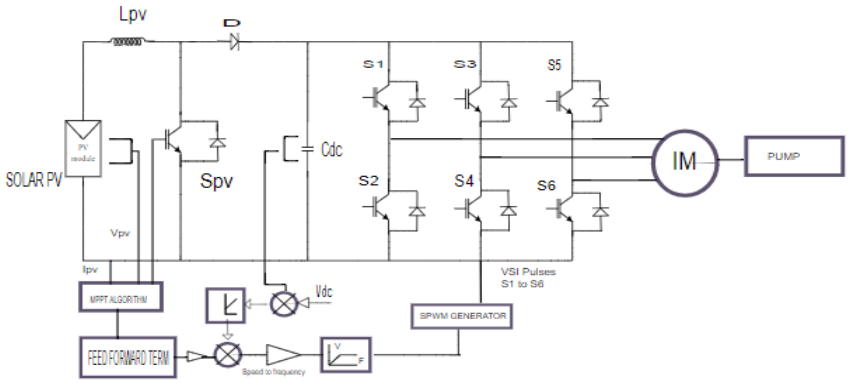

Fig. 2. Circuit diagram of the system

Solar irradiation captured by the panel convert it into electrical energy which is fed to the boost converter. The power from a PV array is managed by an incremental conductance method to attain the maximum value within the accessible radiation. The parameters like voltage, current of the installed PV panels are taken and fed to the INC algorithm. INC algorithm is based on the change in voltage, current it compute the maxim power and required duty ratio for switching he DC-DC converter. Here this algorithm effectively decides the duty ratio of the boost converter and changes in accordance with the calculated value. The output voltage of DC-DC converter, here it is boost converter is maintained to a regulated stable value by the use of a proportional-integral (PI) controller.

The pumps used in this proposed system possess a nature of centrifugal characteristic, the absorbed power of the pump and the working speed has definite relation. A feed forward term used for the speed is calculated from the available PV power and the pump operating factor which is calculated from the rated torque and speed of the motor. The output of the PI controller is subtracted from the speed term. This comparison of PI controller output and the speed term is helpful to reduce the over load on the PI controller and improve the of the system's dynamic performance. The input of the motor and pump assembly is a sine pulse width modulated voltage. The SPWM voltage is provided by using a three-phase VSI. V/f algorithm for speed control employs to realize the switching logic for VSI using sinusoidal pulse width modulation. Induction motor requires smooth starting which is made possible by using V/f control by regulating the starting current. This also will improve the working span of the motor.

In this system two comparisons takes place; first one is within the PI control and the second is the comparison of PI out and the speed term as described early. The first comparison is between the DC link voltage and a given reference voltage. The reference voltage is decided from the inverter requirement. By the comparison if the DC link voltage is become less than the reference voltage then the PI controller will decrease the reference speed given to V/f control and if it is higher than increases the reference

IJIREEICE
ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
NCIET- 2020
National Conference on Innovations in Engineering & Technology
Govt., Polytechnic College, Palakkad, Kerala
Vol. 8, Special Issue 1, February 2020

speed. So the output of first comparison is the reference speed. The comparison of this reference speed and the feed forward speed term is the second comparison. The output of second comparison gives a resultant reference for speed f* for Induction motor drive, which is controlled by V/f control algorithm.

At the beginning the boost converter pulses are kept 0 to operate the system as a single stage converter and the speed is kept ramped to a threshold speed. The control of the boost converter is activated after reaching the threshold speed and as described earlier the duty ratio is computed by INC algorithm. MPPT algorithm gives maximum power even at starting with reduced starting current.

A. Speed Control

V/F control of induction motor is most conman and simple to use. Because of its advantages this algorithm can be used for wide applications. Traditionally induction motors are used for 50Hz supplies. But for speed control, frequency can be varied. The change in frequency should be proportional to change in supply voltage so that the flux will be remains constant [11]. Block diagram below Fig. 3. Shows the V/F control [12]. Here the speed is changed in to frequency and made it proportional to the voltage. This voltage is fed to induction motor via a three phase VSI.

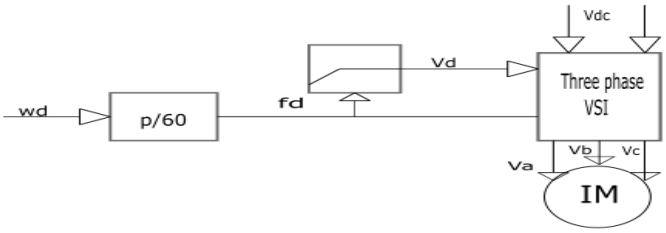

Fig. 3. Block diagram of V/F control method

B. SPWM Control

SPWM switching is used for the control of voltage of the three phase voltage source inverters and the respective gate signals. A fixed dc voltage Vdc is used to fed the VSI .It has three phase-legs each composed of two IGBT switches provided with SPWM control. A sinusoidal signal and a triangular signal are compared and this will controls the switches of VSI. Desired frequency of the inverter output is determined by the sine wave and the switching frequency of the inverter by the triangular wave.

III. SIMULATION RESULTS

Simulations of the converters and the complete pumping system were done using MATLAB/SIMULINK software. The induction motor is controlled by three phase VSI. The switching pulses are given to the VSI using SPWM technique. Simulink model of three phase induction motor using SPWM technique and resultant waveforms are given below

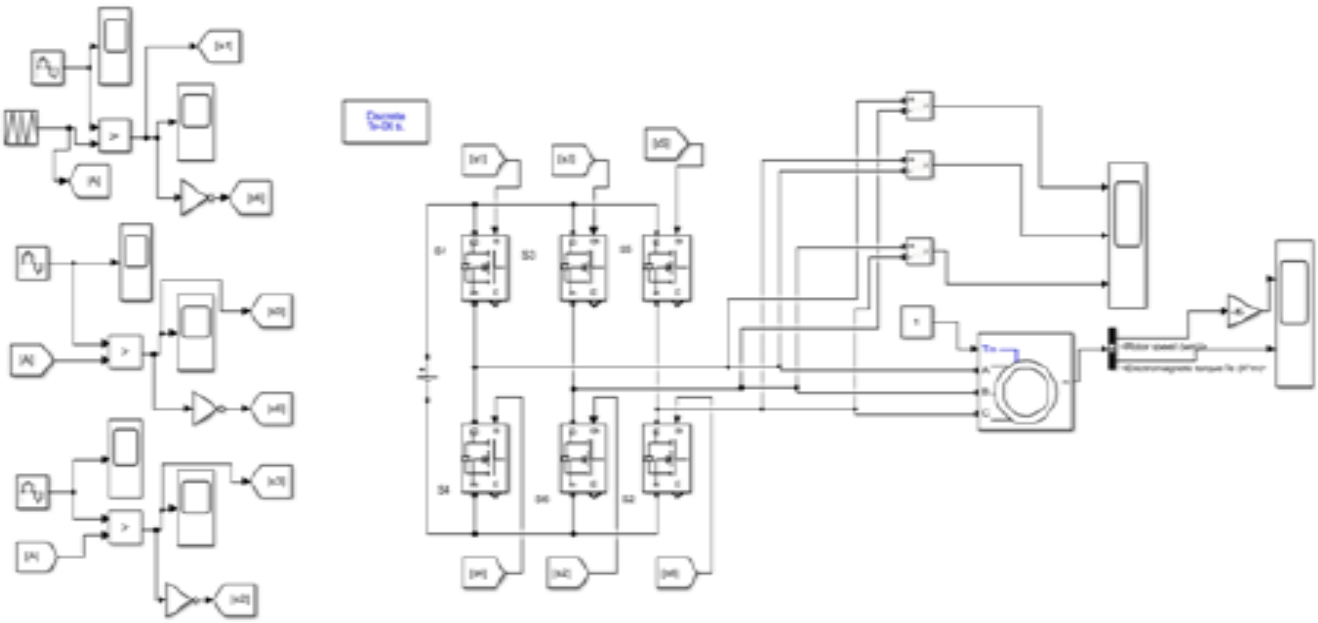

Fig. 4. Inverter with SPWM technique

IJIREEICE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

NCIET- 2020

National Conference on Innovations in Engineering & Technology

Govt., Polytechnic College, Palakkad, Kerala

Vol. 8, Special Issue 1, February 2020

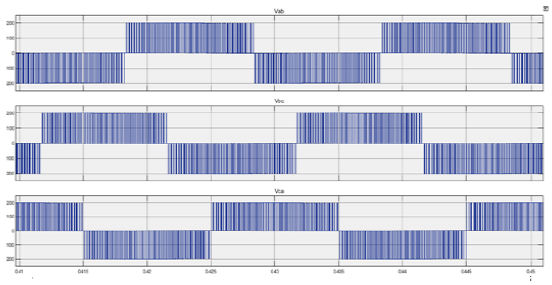

Fig. 5. Voltage waveforms of the three-phase inverter

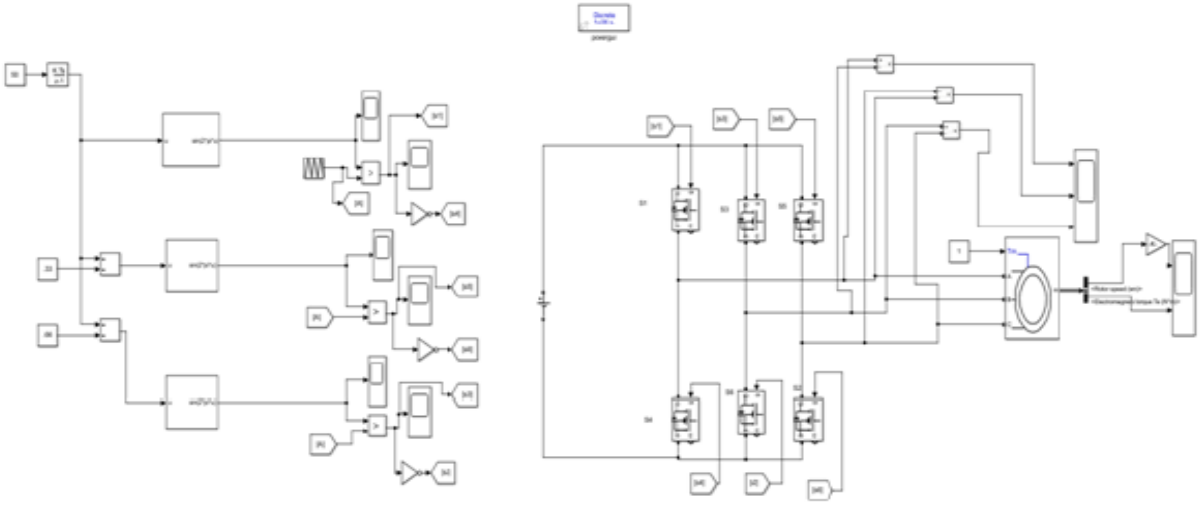

Fig. 6. Induction motor with V/F control

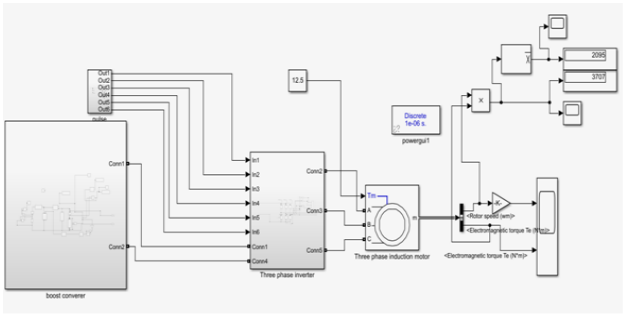

Fig. 8. Simulink model of overall system

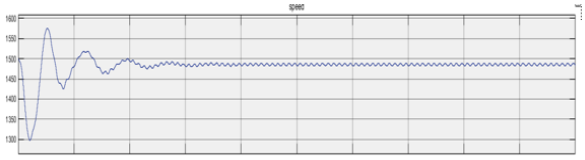

Fig. 9. Rotor speed

In V/F control method the speed can be reduced simply by changing the applied frequency. Fig. 10. Shows the change in rotor speed when the speed is reduced to 40 Hz
From 50 Hz

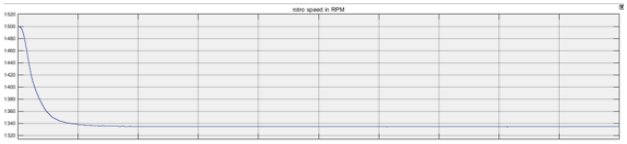

Fig. 10. Change in rotor speed with respect to frequency

IJIREEICE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

NCIET- 2020

National Conference on Innovations in Engineering & Technology

Govt., Polytechnic College, Palakkad, Kerala

Vol. 8, Special Issue 1, February 2020

IV. CONCLUSION

A standalone photo voltaic water pump is proposed. The system is realized using two sensors and employs two conversions for the implementation of the solar water pump. The pump is run by an induction motor and the speed control is achieved through V/F control. The feasibility of the system is verified through simulation. for the simulation results we can see that the motor is run at a stable rated speed and the motor speed can be effectively varied by V/F method. The main advantages of the system are reduced losses and almost stable operation. The sensors used here is also less. In short the system is simple and most reliable and which will be a solution for future energy crisis and is a boon for the isolated areas where electricity cannot be reached.

REFERENCES

[1]. V. Manieniyan, M Thambidurai and R.Selvakumar, "*Study on energy crisis and the future of fossil fuels"*, Proceedings of SHEE 2009, 11-12 Dec'09, Engineering Wing, DDE, Annamalai University
[2]. Chunting.M, Correa M.B. R and J.O.P Pinto, *"The IEEE international future energy challenge-Request for proposals 45"*, 2010 Proc. IFEC 1-24.
[3]. E. Drury, T. Jenkin, D. Jordan, and R. Margolis "*Photovoltaic investment risk and uncertainty for residential customers"*IEEE J .Photovoltaic, vol. 4, no. 1, pp. 278–284, Jan. 2014
[4]. U. Sharma, S. Kumar and B. Singh, "*Solar array fed water pumping system using induction motor drive"*,1st IEEE Intern. Conf. on Power Electronics, Intelligent Control and Energy Systems (ICPEICES),.
[5]. T. Franklin, J. Cerqueira and E. de Santana, "*Fuzzy and PI controllers in pumping water system using photovoltaic electric generation*", IEEE Trans. Latin America, vol. 12, no. 6, pp. 1049-1054, Sept. 2014.
[6]. Ahmed Saeed Ahmed ,Bassem A. Abdullah ,Wahied Gharieb Ali Abdelaal , "*MPPT algorithms: Performance and evaluation*", IEEE Trans. Power Elect., vol. 30, no. 9, pp. 4809-4818, Sept. 2015.
[7]. J. Caracas, G. Farias, L.Teixeira and L. Ribeiro, "*Implementation of a High-Efficiency, High-Lifetime, and Low-Cost Converter for an Autonomous Photovoltaic Water Pumping System*", IEEE Trans. Ind.Appl., vol. 50, no. 1, pp. 631-641, Jan.-Feb. 2014.
[8]. S. Jain, A. K. Thopukara, R. Karampuri and V. T. Somasekhar, "*A Single-Stage Photovoltaic System for a Dual-Inverter-Fed Open-End Winding Induction Motor Drive for Pumping Applications*, IEEE Trans. Latin America, vol. 12, no. 6, pp. 1049-
1054, Sept. 2014.
[9]. R. Antonello, M. Carraro, A. Costabeber, F. Tinazzi and M. Zigliotto, "*Energy-Efficient Autonomous Solar Water-Pumping System for Permanent-Magnet Synchronous Motors"*, IEEE Trans. Ind. Electron.,vol. 64, no. 1, pp. 43-51, Jan. 2017.
[10]. S. R. Baht, A. Pittet and B. S. Sonde, "*Fuzzy and PI controllers in pumping water system using photovoltaic electric generation*", IEEE Trans. Latin America, vol. 12, no. 6, pp. 1049-1054, Sept. 2014.
[11]. Pabitra Kumar Behera, Manoj Kumar Behera, Amit Kumar Sahoo, "Performance Optimization of Induction Motor-Pump System Using Photovoltaic Energy Source"},IEEE Trans. on Ind. App., vol. IA-23, no. 6, pp. 995-1000, Nov. 1987.
[12]. Hanan Mikhael D. Habbi, Hussein Jalil Ajeel,Inaam Ibrahim Ali, "Speed Control of Induction Motor using PI and V/F Scalar Vector Controllers", International Journal of Computer Applications (0975 – 8887) Volume 151 – No.7, October

BIOGRAPHIES

Unnima Unnikrishnan Received B.Tech degree in Electrical and Electronics Engineering from MG University, Kerala in 2018.Currently pursuing M.Tech degree in Power Electronics and Control from APJ Abdul Kalam Technological University, Kerala.

Aneesh V A Received his B.Tech from MA college of Engineering, Kothamangalam and M.Tech from Anna University Regional Centre, Coimbatore in 2008 and 2013 respectively. He served as lecturer in SHM Engineering College, Kadakkal, Kollam from 2009 till 2013 and as Assistant Professor in VKCET, Kollam from 2013 to 2016. He served Kerala State Electricity Board as Sub Engineer from 2016 to 2017 and as Assistant Engineer from 2017 to 2019 .Currently working as Assistant Professor in Electrical & Electronics department in Government Engineering Colleges under Technical Education, Kerala