Solar PV Fed Irrigation Pump

Jayarama Pradeep, Pearl Nightingale. R.H, Mrunal Deshpande

Abstract: Agricultural growth has been severely affected due to the constraints in irrigation-energy deficits. Due to the availability of abundant solar energy especially in India for all days, solar powered irrigation technology has been a promising alternative source compared to canonical electricity and diesel focused pumping systems. How to furnish an electric power suitable to drive an irrigation pump for agricultural purposes in isolated areas using solar PV panels is the problem. This project deals with solving a local irrigation problem in countries. In this proposed project a simple design of simulation and analysis of a PMSM fed by a solar PV, modelled through DC/DC converter controlled by a MPPT and for utilizing the power from Solar. Compared to all converters, luo converters are the advanced technology. POSL luo converter are of new DC-DC step-up converter. This POSL luo converter performs positive to positive DC-DC voltage increasing conversion. The hardware implementation has been done for positive output super-lift luo converter respectively.

Keywords: Permanent Magnet Synchronous Motor (PMSM), Maximum Power Point Tracking (MPPT), Photo Voltaic (PV).

I. INTRODUCTION

The water pumping system for irrigation is of major importance to farmers. With the rising cost of power and the need to use water effectively, its importance have come to the development of technology. Hence, newer and efficient methods to utilize renewable sources of energy are being developed. It is fruitful to integrate renewable sources of energy with water pumping for irrigation. Solar is a cleanest form of energy. It is one of the easiest ways to generate energy where it is difficult to have grid supply. A proper control to extract a constant amount of power irrespective of the environmental changes is extremely important for the success of a PV based system. Hence the incremental conductance technique based MPPT algorithm is utilized through a DC-DC POSL Luo converter in the proposed system. A PMSM can emerge as one of the best alternative over conventional motors. SPWM technique chosen to trigger the Inverter to protect the machine from harmonic effects. The hardware sample model has been put into practice.

TABLE 1: DESIGN VALUES OF PV ARRAY

| Parameter          | Value |
|--------------------|-------|
| OC Voltage, $V_{OC}$ | 150V  |
| SC Current, $I_{SC}$  | 4.8A  |
| Voltage at MPP, $V_{MPP}$ | 125V |
| Current at MPP, $I_{MPP}$ | 4A   |
| Maximum Power, $P_{max}$ | 500W |

B. MPPT

A typical solar panel converts below 5 percent of the occurring irradiation is converted into electrical energy. MPPT is a technique used with PV solar systems to maximize power output. MPP (Maximum Power Point) is the...
product of the MPP voltage ($V_{mpp}$) and MPP current ($I_{mpp}$). In the incremental conductance method, the controller measures the incremental changes in the PV array current and voltage to predict the effect of voltage change. This method requires more computation in the controller.

**MODE 1:**
The first mode is obtained when the switch is ON (closed) and instantaneously, the diode D2 is reverse biased. An equivalent circuit shown in Figure 4.2. When the switch is ON, the diode D1 is forward biased and the inductor L1 is charged by the supply voltage $V_{in}$. The capacitor C1 charges to $V_{in}$. The load is available by the capacitor C2. This mode is also known as the continuous mode of operation.

**MODE 2:**
The second mode is obtained when the switch is OFF (open) and instantaneously, the diodes D1 is reverse biased. An equivalent circuit is shown in the Figure 4.3. When the switch is OFF, the diode D2 is forward biased and the inductor L1 is discharged through the capacitance C1 and C2. The capacitor C2 is charged and supplies the load.

**D. SPWM**
The PWM is a technique which is characterized by the production of unchanged amplitude pulse by regulating the pulse duration by regulating the duty cycle. In the proposed SPWM technique are multiple numbers of output pulse per half cycle and pulses are of different width.

**E. PMSM**
Permanent Magnet Synchronous Motors are generally used in low power agreements such as computer peripheral devices, machine lacking emotions, adjustable speed drives and electric vehicles. The abnormal mass in the market of Permanent Magnet motor drives has claimed for the need of simulation tools efficient of handling motor drive simulations. PMSM are similar to DC motors not using brushes. High achievement of motor control is depicted by smooth rotation over the whole speed range of the motor, torque control at zero speed, faster and slower speed. Simulations have assisted the process of advancing new systems comprehending motor drives, at lower cost and time.

**III. MATLAB SIMULATION RESULTS:**
The Fig.7 represents the MATLAB simulation diagram of the permanent magnet synchronous generator fed by a SPWM controlled inverter fed by a POSL Luo converter, whose duty cycle is fed through the incremental conductance technique of MPPT from the solar PV panel.
The Fig.8 represents the power versus voltage characteristic curve of the solar panel for 1000 W/m² irradiance.

Fig.8 Power versus Voltage Curve of the PV module for 1000 W/m² irradiance

The Fig.9 represents the current versus voltage characteristic curve of the solar panel for 1000 W/m² irradiance.

Fig.9 I-V Curve of the solar cell for 1000 W/m² irradiance

The Fig.10 represents the Motor Speed Characteristics using POSL Luo Converter for 1000 W/m² irradiance

Fig.10 Motor Speed Characteristics using POSL Luo Converter for 1000 W/m² irradiance

The Fig.11 represents the power versus voltage characteristic curve of the solar panel for 800 W/m² irradiance.

Fig.11 Power versus Voltage Curve of the PV module for 800 W/m² irradiance

The Fig.12 represents the current versus voltage characteristic curve of the solar panel for 800 W/m² irradiance.

Fig.12 I-V Curve of the PV module for 800 W/m² irradiance

The Fig.13 represents the Motor Speed Characteristics using POSL Luo Converter for 800 W/m² irradiance

Fig.13 Motor Speed Characteristics using POSL Luo Converter for 800 W/m² irradiance

The Fig.14 represents the power versus voltage characteristic curve of the solar panel for 600 W/m² irradiance.

Fig.14 Power versus Voltage Curve of the PV module for 600 W/m² irradiance
Solar PV Fed Irrigation Pump

Fig.14 P-V Curve of the PV module for 600 W/m² irradiance
The Fig.15 represents the power versus voltage characteristic curve of the solar panel for 600 W/m² irradiance.

Fig.15 I-V Curve of the PV module for 600 W/m² irradiance
The Fig.16 represents the Motor Speed Characteristics using POSL Luo Converter for 600 W/m² irradiance.

Fig.16 Motor Speed Characteristics using POSL Luo Converter for 600 W/m² irradiance
The Fig.17 represents the power versus voltage characteristic curve of the solar panel for 400 W/m² irradiance.

Fig.17 P-V Curve of the PV module for 400 W/m² irradiance
The Fig.18 represents the power versus voltage characteristic curve of the solar panel for 400 W/m² irradiance.

Fig.18 I-V Curve of the solar cell for 400 W/m² irradiance
The Fig.19 represents the Motor Speed Characteristics using POSL Luo Converter for 400 W/m² irradiance.

Fig.19 Motor Speed Characteristics using POSL Luo Converter for 400 W/m² irradiance
The Fig.20 represents the power versus voltage characteristic curve of the solar panel for 200 W/m² irradiance.

Fig.20 P-V Curve of the PV module for 200 W/m² irradiance
The Fig.21 represents the current versus voltage characteristic curve of the solar panel for 200 W/m² irradiance.

Fig.21 I-V Curve of the solar cell for 200 W/m² irradiance
The Fig.22 represents the Motor Speed Characteristics using POSL Luo Converter for 200 W/m² irradiance

![Fig.22 Motor Speed Characteristics using POSL Luo Converter for 200 W/m² irradiance](image)

TABLE 2: Output Parameter Specification And Values Obtained

| Irradiance (W/m²) | Ipv (A) | Vpv (V) | Ppv (W) | Vout (V) | Speed (rpm) |
|-------------------|---------|---------|---------|----------|-------------|
| 1000              | 10.02   | 133.9   | 1341.6  | 297.9    | 1550        |
| 800               | 8.218   | 132.9   | 1092.1  | 290      | 1518        |
| 600               | 8.259   | 129.4   | 1068.7  | 285.1    | 1478        |
| 400               | 8.138   | 124.6   | 1013.9  | 271.1    | 1432        |
| 200               | 8.023   | 120.6   | 967.5   | 269.1    | 1395        |

IV. HARDWARE SETUP:

The hardware experimental setup of the POSLLC has been shown.

![Fig.23 Hardware Experimental Setup](image)

Fig.23 Hardware Experimental Setup

![Fig.24 Hardware Output of the Duty Cycle](image)

Fig.24 Hardware Output of the Duty Cycle

Thus, the project represents the simple design of a solar water pumping framework using permanent magnet synchronous motor fed by a solar PV array. The system is simulated by using MATLAB/Simulink. The simulation result of the motor and output voltage of the converter obtained for different irradiations had been tabulated correspondingly. The hardware topology for the Positive Output Super-Lift Luo Converter has been implemented.

REFERENCES

1. Ahmed Th. Mohsin, Isam M. Abdulbaqi, “Analysis of an Irrigation Pump Driver Fed by Solar PV Panel”.
2. Zeng-li Shan, Shuo Liu, Fang Lin Luo, “Investigation of a Super-Lift Luo-Converter used in solar panel system”.
3. Anandhi S, “Implementation of Photo Voltaic Based Improved Negative Output Self-Lift Luo Converter Using Particle Swarm Optimization”.
4. Anjana.A.R, M.Sindhura, C.H.Taran, Mini Sujith, “Solar Powered Luo Converter Fed Three Phase Induction Motor for Water Pumping System”.
5. B.ArunKumaran, C.S.Ajin Sekhar, V.Bala, “Pv Powered Quasi Z-Source Inverter For Agricultural Water Pumping System”.
6. Shabab Murshid, Bhim Singh, “Double Stage Solar PV Array Fed Water Pump Driven Br Permanent Magnet Synchronous Motor”.
7. Harjot Singh, L.Bharat Kumar, Saxena, K. V. S. Rao, “Performance Study of a Solar Photovoltaic Water Pump used for Irrigation at Jaipur in Rajasthan, India”.
8. Nandikesh Pushpajr, Nitin Gupta, Vikas Gupta, “Solar Energy Harvesting for Irrigation Water Pumping System”.
9. Ion Sobor, “Photovoltaic Pump System Design for Small Irrigation”.
10. U.Jayashree, Pearl Nightingale.R.H, S.Divya, “Implementation of Basic MPPT Techniques for Zeta Converter”.

AUTHORS PROFILE

Jayarama Pradeep (Member, IEEE) received her B.E (Electrical and Electronics Engineering) from Madras University, M.E (Power Electronics and Drives) from Sathyabama University, and Ph.D. in electrical engineering from the Sathyabama University, Tamilnadu. She is the Professor and Head of the Department in Electrical and Electronics department of St.Joseph’s College of Engineering, Chennai. She has 21 years of teaching experience. Her research interests include power electronics and drives, electrical machines, and control.

Pearl Nightingale.R.H obtained her B.E (Electrical and Electronics Engineering) and her M.E (Power Electronics and Drives) from St.Joseph’s College of Engineering, Chennai. She has published papers in International Conferences and her areas of interest include Solar, Electrical Machines and Power Electronics. Currently, she is working as Research Assistant in Department of EEE, SSN College of Engineering Chennai, Tamilnadu, India.

Dr. Mrunal Deshpande acquired her B.E (Electrical and Electronics Engineering) from Nagpur University and her M.E (Applied Electronics) and Ph.D from Anna University, Chennai. She has been in teaching field for more than 23 years. She has published many papers in International Journals and International Conferences. Her areas of interest include Non linear control systems, Electrical Machines and drives and Power Electronics. Currently, she is working as Associate Professor in Department of EEE, SSN College of Engineering Chennai, Tamilnadu, India.