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RESEARCH ARTICLE OPEN ACCESS

Solar PV based Vector Controlled Induction Motor Drive for renewable energy application.

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ABSTRACT
Solar Photovoltaic array for renewable energy application incorporates perturb and observe algorithm fed boost converter and vector control fed induction motor drive algorithm. The system deals with the implementation of Perturb and observe (P&O) algorithm to extract maximum power point to control duty ratio of boost converter. A vector controlled voltage source inverter operates induction motor drive. The system is designed and simulated in MATLAB/Simulink software. The two proposed individual control algorithm works effectively. The results are demonstrated for verification.

Keywords - Solar Panel, Maximum power point tracking (MPPT), vector control, induction motor drive.

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I. INTRODUCTION

The requirement for non-conventional energy sources is arising because of severe energy disaster in world today. Renewable energy sources is economical and solar energy is inexpensive and most abundantly used in subcontinent. When a photovoltaic cell is illuminated by sunlight electrical power is generated. Due to high expenditure cost of solar PV panels, their application is moderate. Two stage topologies for renewable energy system require fewer number of power semiconductor switches, thus their switching losses reduces. The drawback of single stage system is that indispensable PV cells are connected in series or parallel to form as a panel at input side hence cost equipment increases naturally. Hence to overcome this downside, to reduce number of PV cells boost converter and increase voltage level by varying duty cycle. Input is taken from PV system and output is given to inverter switches. Boost converter output is given to inverter which is operated by vector control. To control the Induction motor drive tied Voltage source inverter for renewable energy application many speed control technique are their, such as frequency control, scalar control, vector control or feed-forward vector control, Direct Torque Control (DTC). But for good start of induction motor, vector control method is effectual. FOC is based on decoupling of torque and rotor flux, hence dynamic performance of AC motors can be seen. This method helps to vary the speed and shows a good torque performance. It consist of voltage source converter, three phase Induction motor drive is used because high efficiency of energy conversion, they are highly robust and rugged in construction. They have a high starting torque. The scalar variable frequency drive performance is not much compatible, so we are using vector control of induction motor drive. It assures smooth operation. MPP is tracked by using perturb and observe system fed boost converter [1]-[3].

II. INDENTATIONS AND EQUATIONS

Proposed system consist of two stages PV panel followed by a boost converter duty ratio control is done by using perturb and observe method which successfully tracks maximum power with available radiation. The switching pulses followed by indirect vector control are fed to VSI for Induction motor. Each system consist of separate regulation rule [2].

Perturb and observe method for MPPT-
The computation of PV output power and examination of PV voltage and current is done by using perturb and observe algorithm. In this maximum power is traced by regularly increasing or decreasing solar array voltage. The duty ratio of dc chopper is assorted and steps are performed up to the maximum power is outstretched. The previous power P_{old} and new power P_{new} are collated to increase or decreases [4].

For different values of temperature and irradiance, the PV array exhibit characteristic curves. Hill climbing perturbation on the duty cycle of the

power converter and (P&O). In this algorithm the disruption is introduce to the system and hence solar power varies accordingly. perturbation is continued. If power increases perturbation is continued and maximum power point reaches zero and immediately decreases and perturbation reverses as shown in figure 1.

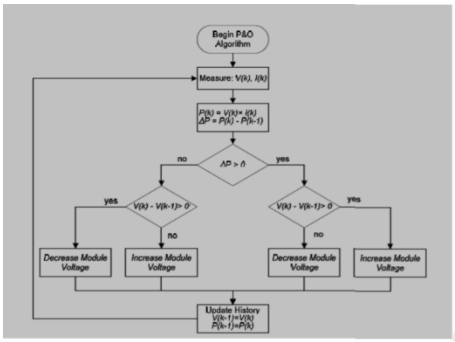

Fig 1. Flowchart of perturb and observe method

Indirect Field oriented control of Induction Motor- In Vector Control the position of voltage, current, and flux space vector are controlled, giving correction in both in steady and dynamic state. Two types of vector control are their first is direct field oriented control and additional one is indirect field oriented control. The variation between two techniques is that calculation of unit vector generation $\cos\theta_e$ & $\sin\theta_e$ and its control. Two main components are torque component (i_{qs}^*) and flux component (i_{ds}^*). Rotor flux orientation in a squirrel-cage induction machine is difficult to measure Since DC machine-like performance control of ac drives, vector control technique entitle decoupling, orthogonal, or transvector control. Vector control drives various speed control technique scalar control, and it is received as industry-level standard control for ac drives. Equation for estimating rotor flux [5].

$$\Psi_r = \frac{L_m * (I_{ds})}{1+T_r} \quad (1)$$

Above calculation is done on basis of motor equation composites. To calculate θ_e rotor-field angle with respect to stator a -axis, ω_e is speed of rotor field reference is integrated we get equation as,

$$\theta_e = \int \omega_e dt = \int (\omega_r + \omega_m) d_t = \theta_r + \theta_{sl} \quad (2)$$

Sum of rotor speed in electrical rad/sec and slip speed gives

$$\omega_r = \frac{L_m}{\Psi_r T_r} i_{qs} \quad (3)$$

I_{qs} calculation from torque reference T_e^*.

$$i_{qs} = \frac{2}{3} * \frac{2}{P} * \frac{L_r}{L_m} * \frac{T_e^*}{\Psi_r} \quad (4)$$

From torque reference Te* the stator quadrature-axis current reference is calculated.

$$i_{ds} = \frac{\Psi_r}{L_m} \quad (5)$$

Where L_r is rotor inductance, L_m is mutual inductance, φ_r is the estimated rotor flux linkage. Phase variables a, b, c into d_q components of the rotor flux rotating field reference frame. Inverse park transformation performs the conversion a, b and c phase variables [5].

$$\begin{pmatrix} V_{qs}^s \\ V_{ds}^s \end{pmatrix} = 2/3 \begin{pmatrix} 1 & -0.5 & -0.5 \\ 0 & -sqrt3/2 & -sqrt3/2 \end{pmatrix} \begin{pmatrix} Vas \\ Vbs \\ Vcs \end{pmatrix}$$

Component of current corresponding to stator input i_{ds} is calculated by dividing the rated flux Ψ_r with L_m and torque can be expressed as

$$T_e = \frac{3}{2} * p * \frac{L_m}{L_r} * (\Psi_{dr} i_{qs}) \quad (6)$$

Two phase stator currents (i_q , i_d) are transformed into three phase stator reference currents (i_a, i_b, i_c) using Clarks transformation as,

$$i_a = i_d \quad (7)$$

$$i_b = -\frac{1}{2} * i_d - \frac{\sqrt{3}}{2} * i_q \quad (8)$$

$$i_c = -\frac{1}{2} * i_d + \frac{\sqrt{3}}{2} * i_q \quad (9)$$

The reference stator currents (i_a, i_b, i_c) and actual stator currents (i_{as}, i_{bs}, i_{cs}) subtracted and the error is given to hysteresis current controller. Gate signal provided to VSI are created with the help of hysteresis current controller to drive the motor. The Current regulator is a bang-bang current controller in which bandwidth vary. The three hysteresis controllers which consist actual current is built with simulink block. In hysteresis type relay actual motor current are taken from asynchronous machine block. Hence comparison of actual motor current and reference current is done [6]-[8].

III. FIGURES AND TABLES

Induction motor drive fed by solar PV array is a proposed system put forward in MATLAB's simulation tool simulink which is helpful to complete model. Starting and stable state characteristic of the system is studied under rated insolation 1000W/m^2. The category of Solar PV array is chosen larger than motor rating to keep motor performance unaffected also to control reimbursement of incurred losses from dispatch to gaining.

Case 1=1000W/m^2; For 100% Tl=14.2 N.m

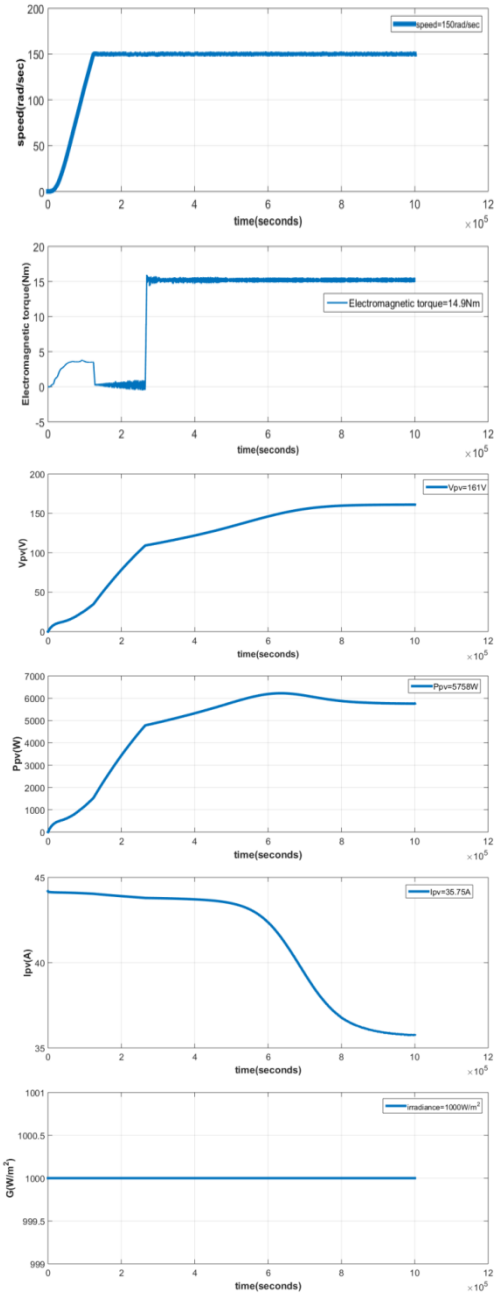

Fig 2. Starting characteristic and system representation at 1000W/m^2 Solar PV array parameters. Under rated insolation level 1000W/m^2. When MPP is reached, PV voltage and current reach their top values the motor is started smoothly the generated electromagnetic torque is 14.9N.m. The motor speed (ω_m) follows the reference speed (ω_{ref}), it achieves 150rad/s in quick sequence.

Case 2=1000W/m^2; For 50% Tl=7.4 N.m

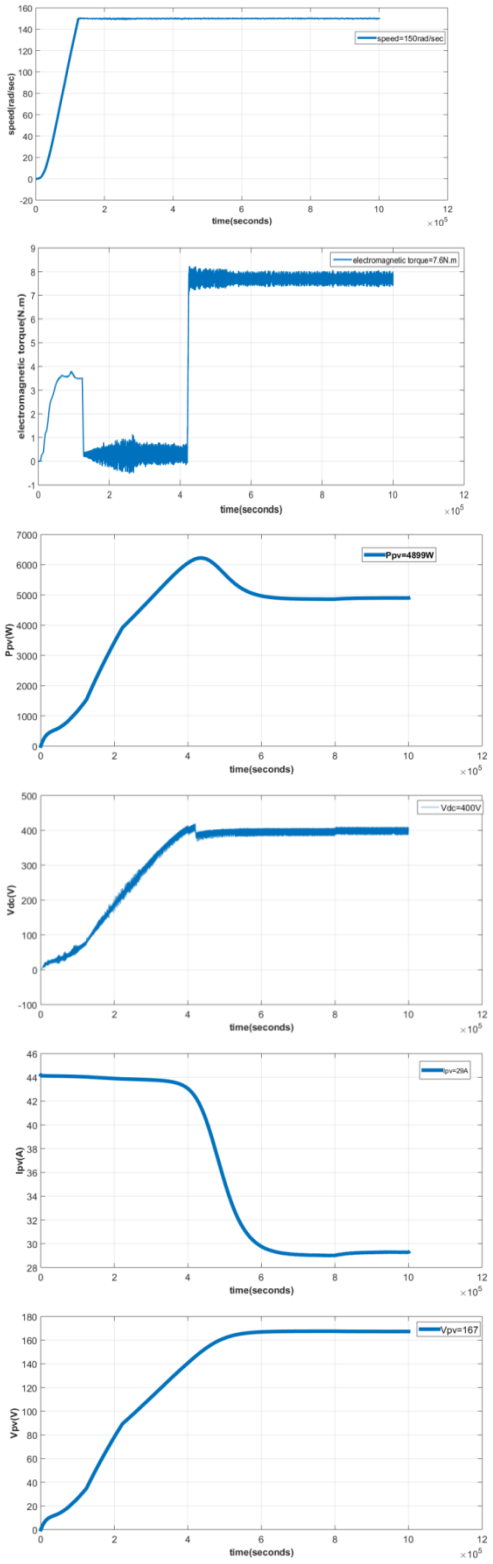

Fig 3. Starting characteristic and system representation at 1000W/m^2 Solar PV array parameters.

IV. CONCLUSION

This paper shows double stage in proposed system each system consist of separate control algorithm. Inspite of atmospheric variation MPPT algorithm based on perturb and observe fed solar PV array reaches. Even and dynamic response is achieved within time by giving switching pulses with help of Indirect vector control technique to inverter. Hence switching order achieves desired electromagnetic torque at motor shaft. In this paper clear study of two stages PV system is done using MATLAB/Simulink Software. This paper shows that motor produces sufficient electromagnetic torque to drive the load. Speed is reached with good precedence.

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