Dynamic Performance of PV Array fed Vector Drive Unit

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ABSTRACT—In emerging applications of solar powered units the significance of its operation and control plays vital role. Industries to home, in all applications need induction motors due to its robust, simple and reliable so this type of machines used widely in variable speed applications. In the scenario this paper presents the operation and dynamic performance of vector drive fed by PV array. Any drive unit equipped with power management unit, signal conditioning, drivers and controllers and control unit. This system powered by the excitation from PV array with MPPT controller and the load here is a vector drive. Vector control is advantageous over scalar control due to its low speed regulation, low maintenance and minimum speed at Rated torque and wide base speed range. The proposed system consists of PV array, MPPT Controller, vector controlled drive. Solar panel output boosted using DC-DC converter with Maximum power point tracking controller Using Incremental Conductance method and the performance curves (P-V, I-V, V-I) presented. Dynamic modelling and analysis of Individual units and the respective performance curves presented here and the simulations done in MATLAB/SIMULINK Platform.

Keywords: PV array, MATLAB software, MPPT, Vector Control, Induction Motor

I. INTRODUCTION

Power scarcity in some areas becoming a major problem and it can be nullified significantly using solar energy as it is free and available in all sunny days but it is intermittent in nature. To overcome this problem, Mechanical solar tracking máxima power point tracking control system is used to extract maximum solar energy. So, clean energy sources are inevitable now. [2][3] Due its robustness and simple construction induction motors with appropriate control is used widely in industries. Harmonics are the issue in the motor. By using multilevel inverters the THD levels can be reduced so that the operational and harmonics effects reduced. [1][4] Some authors Explains the operation of indirect foc with multilevel inverter to reduce harmonics produced in the drive unit. [1]- [6] Satish explained Space vector modulation technique and the way it improves the task required.

Tracking systems are used to maximize the output coming from solar source. In these Systems there Exists mechanical and electrical solar tracking systems. In paper [10] author well explained the process of Hybrid controlled mechanical and electrical tracking systems. In paper [11] Author brief us regarding the role of multilevel inverter in present era and connected it to wind energy source. Though several authors explained the role of renewables and their usage, I attempted a task to Integrate Drive unit with solar supply that is what I called as solar powered vector controlled drive.

Methodology:

Section 1:

In this section, National and international work done towards the research topic presented.

Section 2:

In the particular section, we elaborated the proposed idea and respective performance analysis of PV array with MPPT control presented.

Section 3:

Here, We presented the operation of vector controlled drive and its dynamic performance evaluated.

Section 4:

It deals with the Concluded Results and contribution of proposed Work.

II. SCHEMATIC DIAGRAM OF PROPOSED SYSTEM

Figure 1: Schematic diagram of proposed system

Solar power requirements:

Solar panel equipped with the battery to store the energy extracted from the solar. Calculating the size and level of voltages as per the following formulae

Size of battery in (ampere-hour) * battery voltage = available power. Let us take an example to understand this battery size is 30 amp-hours and voltage of 12V then the battery could be able to supply (30* 12=360 Wh). i.e., it supplies 360 watts for one hour and 120 watts for 3 hours. Worth mentioning point here is drawing more energy led to discharge battery very quickly. In view of that a lead acid battery gives 50% of its rated power and Li-ion battery provides 80% of its rated power.
Power management Unit:

In the proposed system the power management system consists of pv array with MPPT controller which feeding Induction motor vector controlled drive. The respective PV System modelling and the performance curves exhibited here and these performance curve analysis done in MATLAB Simulink platform.

A. PV Array with MPPT Control

![Schematic diagram of PV array with MPPT](image)

**Electrical solar Tracking systems (MPPT):**

Electrical solar tracking systems means Maximum Power point tracking system used to control the duty and get Maximum power at every instant. This is possible by using several methods such as Perturb and Observe, Incremental Conductance Method and fractional open circuit Voltage method. Though they are all having their respective advantageous, here we are presenting Incremental Conductance method due to its robustness.

![Flow diagram of Incremental Conductance Method](image)

**B. Simulation diagram of PV system in MATLAB Software:**

![Simulation diagram of PV system](image)

![V-I performance curves of PV system](image)

![P-I performance curves of PV system](image)

![P-V performance curves of PV system](image)
Step 2: current is now converted into two coordinate system components in rotor reference frame
Step 3: Rotor position is sensed by speed measurement sensor.
Step 4: Rotor flux vector is estimated by Lm* Stator current
Step 5: finding the ratio of rotor inductance to rotor resistance i.e., nothing but No load Rotor Time constant
Step 6: current vector converted into two coordinate system components as below

\[
V_d = \frac{2}{3} \left[ V_a \cos \theta + V_b \cos \left( \theta - \frac{2\pi}{3} \right) + V_c \cos \left( \theta + \frac{2\pi}{3} \right) \right]
\]
\[
V_q = \frac{2}{3} \left[ V_a \sin \theta + V_b \sin \left( \theta - \frac{2\pi}{3} \right) + V_c \sin \left( \theta + \frac{2\pi}{3} \right) \right]
\]

\[
dq - abc (Clarke transformation) equations:
V_a = V_d \cos \theta - V_q \sin \theta
V_b = V_d \cos \left( \theta - \frac{2\pi}{3} \right) - V_q \sin \left( \theta - \frac{2\pi}{3} \right)
V_c = V_d \cos \left( \theta + \frac{2\pi}{3} \right) - V_q \sin \left( \theta + \frac{2\pi}{3} \right)
\]

Step 7: calculating d, q axis current components and PI controllers are used to control these currents
Step 8: Now dq components of voltage coordinate system converted to \((\alpha, \beta)\) coordinate system.
Step 9: Voltage components in \((\alpha, \beta)\) converted into (a,b,c) coordinate system
Step 10: Now signaling the power inverter using these pulses.

B. Vector controlled drive system simulation:

III. VECTOR CONTROLLED DRIVE UNIT & RESULTS

A. Vector control:

It is the technique for controlling a variable frequency of the stator in Induction motor drive in which two orthogonal components present. One describes the performance of Torque as determined by the speed of motor. For fast acceleration and deacceleration field oriented control is widely used over scalar control. In vector control drive sensor less type in which sensors are replaced by taking the data as reference from the extracted voltage and current values from the rotor and fed those values to the current control of motor.
Step 1: Stator currents are measured and converted those currents into three phase coordinate system
C. Vector controlled drive system performance:

![Figure 11: Stator current and rotor speed of drive unit](image)

![Figure 12: Electromagnetic torque of drive Unit](image)

![Figure 13: Gate pulses of inverter in drive unit](image)

**Motor specifications:**

- Nominal power $P=7000$;
- Nominal Voltage $v=460$;
- Frequency $f=50$;
- Stator resistance $R_s=14.85e-3$;
- Stator leakage inductance $L_s=0.3027e-3$;
- Rotor resistance $R_r=90295e-3$;
- Rotor Inductance $L_r=0.3027e-3$;
- Time response $T_r=L_r/R_r$;
- Mutual Inductance $L_m=10.46e-3$;
- Moment of inertia $J=3.1$;
- Number of poles $P=2$;
- Proportional gain $k_p=16600$;
- Integral gain $k_i=27700$;

**IV. CONCLUSIONS**

The paper focuses on the dynamic performance of Vector controlled induction motor which is widely used in Industries. The proposed system is powered by using one of the clean energy Resource i.e solar. The maximum power extracted from the PV panel is boosted here using DC-DC converter and the respective duty is controlled by MPPT control. Incremental Conductance method is used here and control algorithm also incorporated. This proposed system well suited for PV driven individual units and propulsion vehicles. The test results and the performance characteristics exhibited here.

**REFERENCES**

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