Dynamic Performance of PV Array fed Vector Drive Unit

R.SrinuNaik, Aravelli .S.L.K.Gopalamma

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/maximum 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

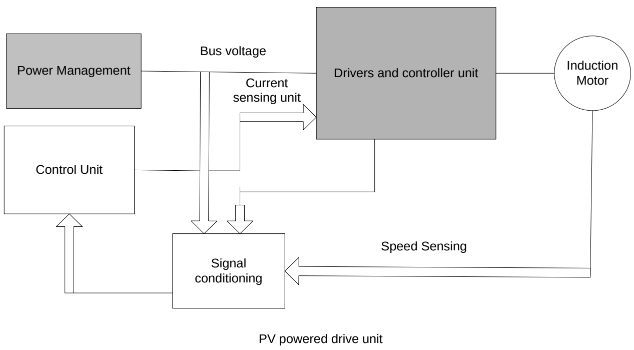

Figure 1: Schematic diagram of proposed system

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).

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i.e., it supplies 360 watts for one hour and 120watts 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 exhibitedhere and these performance curve analysis done in MATLAB Simulink platform.

A. PV Array with MPPT Control

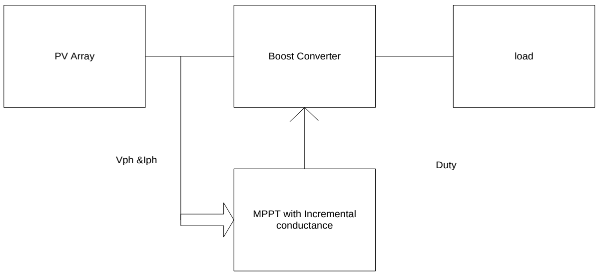

Figure 2: Schematic diagram of PV array with MPPT

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.

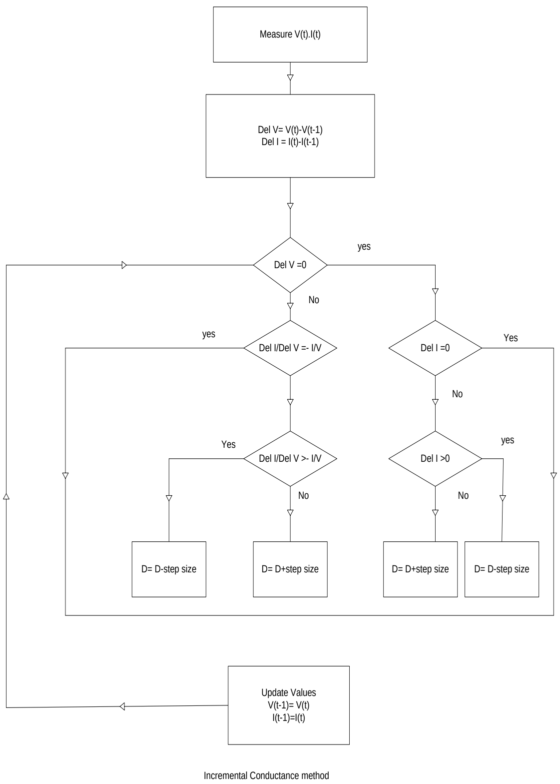

Figure 3: Flow diagram of Incremental Conductance Method

B. Simulation diagram of PV system in MATLAB Software:

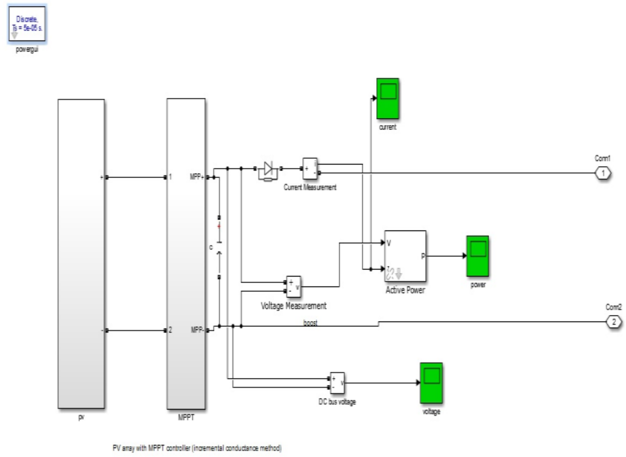

Figure 4: Simulation diagram of PV system

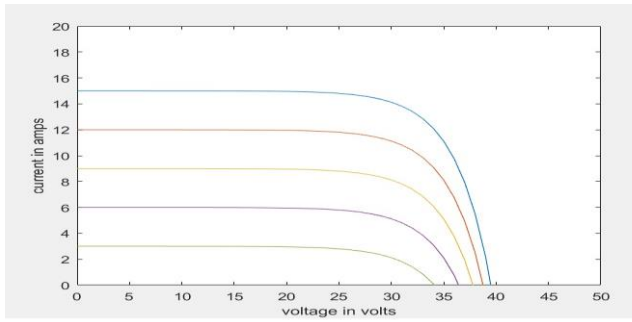

Figure 5: V-I performance curves of PV system

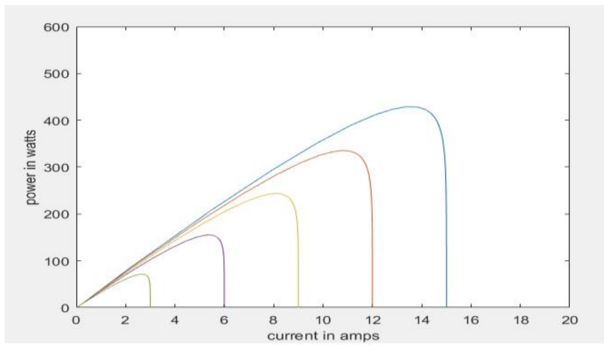

Figure 5: P-I performance curves of PV system

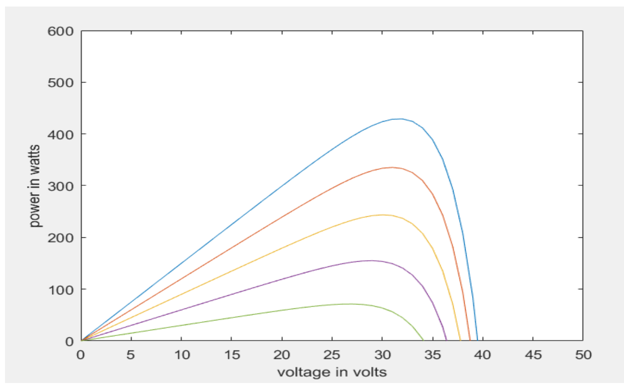

Figure 6: P-V performance curves of PV system

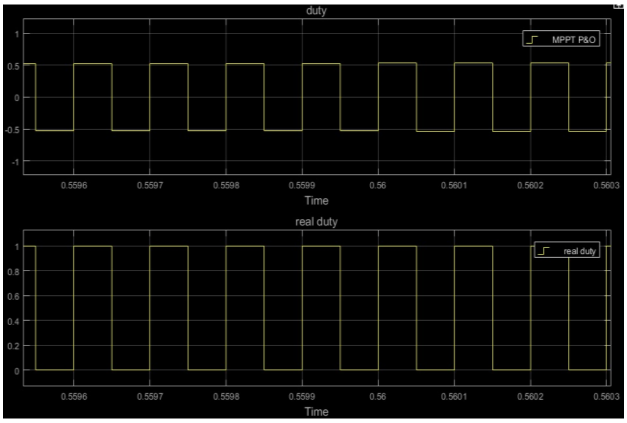

Figure 7: Duty of MPPT controller

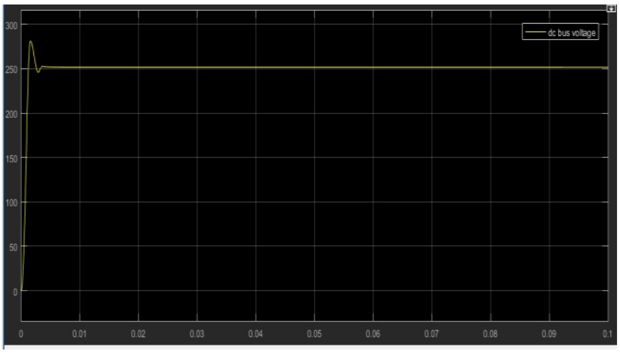

Figure 8: dc bus voltage at PV system output

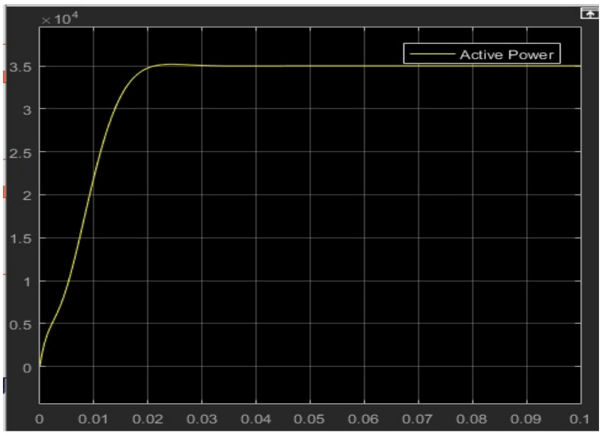

Figure 9: Active power output at PV system

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

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

abc-dq (park transformation) equations:

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

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

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($\boldsymbol{\alpha}$,$\boldsymbol{\beta}$) coordinate system.

Step 9: Voltage components in (,$\boldsymbol{\beta}$) converted into (a,b,c) coordinate system

Step 10: Now signaling the power inverter using these pulses.

B. Vector controlled drive system simulation:

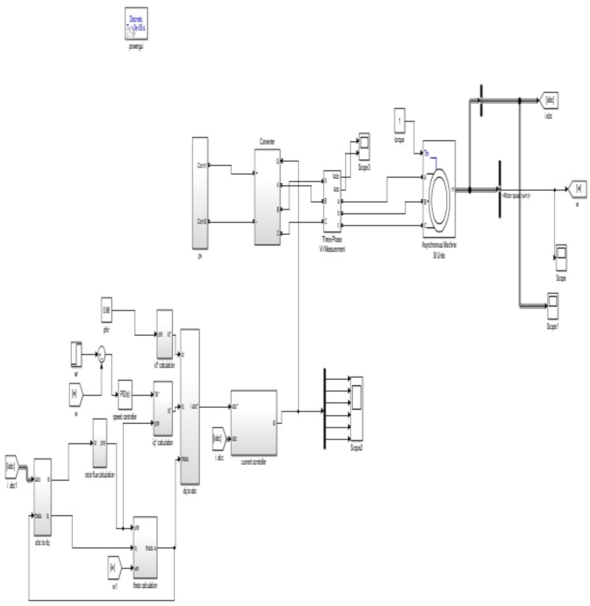

Figure 10: Simulink model of Vector controlled drive unit

C. Vector controlled drive system performance:

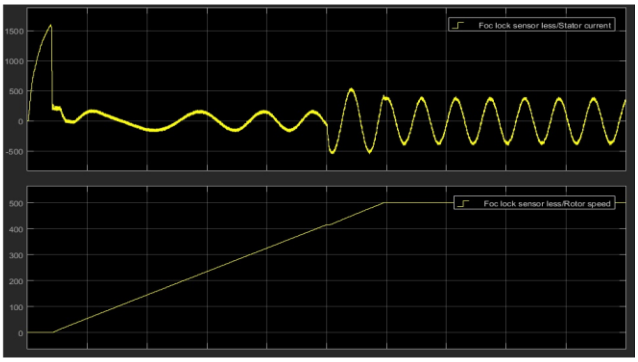

Figure 11: Stator current and rotor speed of drive unit

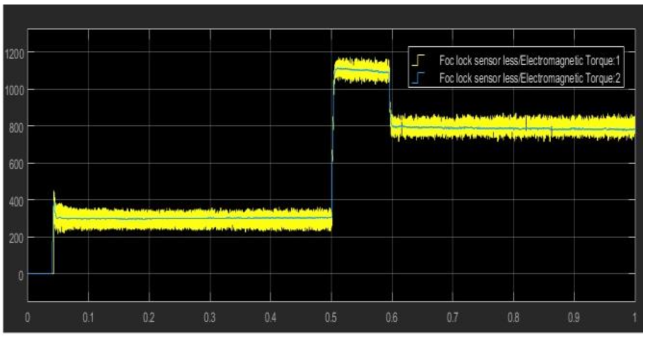

Figure 12: Electromagnetic torque of drive Unit

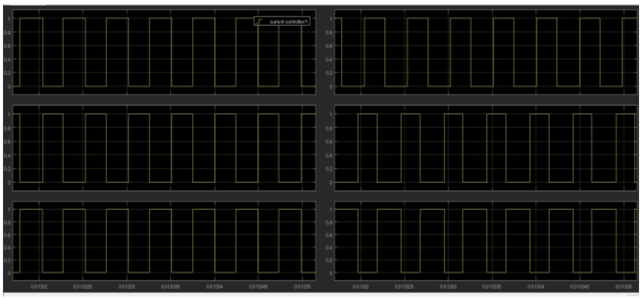

Figure 13: Gate pulses of inverter in drive unit

Motor specifications:

Nominal power p=7000;
Nominal Voltage v=460;
Frequency f=50;
Stator resistance Rs=14.85e-3;
Stator leakage inductance Ls=0.3027e-3;
Rotor resistance Rr =90295e-3;
Rotor Inductance Lr =0.3027e-3;
Time response Tr=Lr/Rr;
Mutual Inductance Lm=10.46e-3;
Moment of inertia J=3.1;
Number of poles P=2;
Proportional gain kp =16600;
Integral gain ki =27700;

IV. CONCLUSIONS

The Paper focusses 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

1. Indirect vector control of induction motor using a five-level cascaded H-bridge inverter,Salma,Abdellah Mustapha 00978-1-5386-7328-7/18/$31.00 c 2018 IEEE
2. Photovoltaic Pumping System using SVPWM based Induction Motor Drive with a High Gain Converter 1.Niravadya V S.,2.Caroline Ann Sam.,3.Dr.Elizabeth Rita Samuel, Proceedings of the 2nd International Conference on Inventive Communication and Computational Technologies (ICICCT 2018) IEEE Xplore Compliant - Part Number: CFP18BAC-ART; ISBN:978-1-5386-1974-2
3. J. M. Caracas, G. D. C. Farias, L. M. Teixeira, and L. de Souza Ribeiro, "Implementation of a High-Efficiency, High-Lifetime, and Low-Cost Converter for an Autonomous Photovoltaic Water Pumping System," IEEE Transaction on Industrial. Applications., vol. 50, no. 1, pp. 631– 641, Jan.-Feb. 2014.
4. H.Sathishkumar,Dr.S.S.Parthasarathy," Space Vector Pulse Width Modulation for DC-AC converter" IEEE International Conference On Science Technology Engineering and Management (ICONSTEM)2016
5. Li, Guihua, Runsheng Tang, and Hao Zhang. International Conference on Future Energy, Environment and Materials 16 (2012): 1744–1752.
6. Books: Solar Tracking: High precision solar position algorithms, programs, software and source-code for computing the solar vector, solar coordinates & sun angles in Microprocessor, PLC, Arduino, PIC and PC-based sun tracking devices or dynamic sun following hardware by gerro j prinloo,robertthomas Dobson(2015)
7. 9. Mousazadeh, H., Keyhani, A., Javadi, A., Mobli, H., Abrinia, K., Sharifi, A Renewable and Sustainable Energy Reviews, Jan. 2009. Vol 13, issue 8, pp.1800-1818.
8. L. M. Elobaid, A. K. Abdelsalam, and E. E. Zakzouk, "Artificial neural network based maximum power point tracking technique for PV systems," in Proceedings of the 38th Annual Conference on IEEE Industrial Electronics Society (IECON '12), pp. 937–942, Montreal, Canada, October 2012.
9. T. Esram and P. L. Chapman, "Comparison of photovoltaic array maximum power point tracking techniques," IEEE Transactions on Energy Conversion, vol.22,no.2,pp.439–449,2007.
10. Aravelli s l k gopalamma,Dr.R.srinu Naik " Hybrid loop controlled dual axis mechanical solar tracking systems and MPPT for Nano/Micro grid Applications" international Journal of Engineering and Avance Technology IJEAT ISSN :2249-8958,Volume 8,Issue 6S3,September 2019.
11. K.rachananjali,R.srinu naik, K.Bala krishna "Implementation of Modular Multilevel Inverter for Extraction of Wind energy" Journal of Green engineering volume-9,Issue 3, october 2019.

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