

A NOVEL DC-DC CONVERTER BASED CLOSED LOOP CONTROL OF BLDC MOTOR FOR SPV FED WATER PUMPING SYSTEM

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Abstract— This Paper Presents Novel DC-DC Converter Based Closed Loop Control of BLDC Motor for SPV fed Water Pumping System Solar Photovoltaic (SPV) Array fed Water pumping System Utilizing Buck-boost DC-DC Converter in order to extract the maximum available power from Solar system. Solar energy has the greatest availability compared to other energy sources. For such solar PV systems, maximum power point tracking control is preferred for efficient operation. This concept is dealing with INC method which is one of the MPPT methods. This study deals with a buck-boost converter controlled solar photovoltaic (SPV) array fed water pumping in order to achieve the maximum efficiency of an SPV array and the soft starting of a permanent magnet brushless DC (BLDC) motor. The current sensors normally used for speed control of BLDC motor are completely eliminated. The speed of BLDC motor is controlled through the variable DC-link voltage of a voltage-source inverter (VSI). The VSI is operated by fundamental frequency switching, avoiding the losses due to high-frequency switching, in order to enhance the efficiency of the proposed system.

Keywords— *BLDC Motor, Solar PV Array, Buck-Boost Converter, Incremental & Conductance MPPT Method, Voltage source Inverter*

1.Introduction

Severe environmental protection rules, shortage of fossil fuels and eternal energy from the sun have impelled the researchers towards the star electrical phenomenon (SPV) array generated power for numerous applications [1]. Water pumping is receiving wide attention today amongst all the applications of SPV array. to reinforce the potency of SPV array and therefore the entire system despite the operative conditions, it becomes essential to control SPV array at its most PowerPoint by suggests that of a most electric outlet following (MPPT)algorithm [2-4]. numerous DC-DC converters are already used to accomplish this action of MPPT. The PV inverters dedicated to the little PV plants should be characterised by an outsized vary for the input voltage so as to just accept completely different configurations of the PV field. This capability is assured by adopting inverters supported a double stage design wherever the primary stage, that sometimes may be a dc/dc convertor, is accustomed adapt the PV array voltage so as to fulfill the necessities of the dc/ac second stage, that is employed to provide Associate in Nursing ac load or to inject the made power into the grid. This configuration is effective additionally in terms of controllability as a result of the primary stage is dedicated to track the utmost power from the PV array, whereas the second stage is employed to provide ac current with low Total Harmonic Distortion (THD). BLDC motors ar most popular over DC motors and induction motors thanks to their benefits like long operative life, higher potency, low maintenance and higher speed torsion characteristics. mechanical device windings of BLDC motors ar energized {in a|during|in Associate in Nursing exceedingly|in a very} sequence from an electrical converter. A bulkier DC link condenser is connected in between the dc-dc convertor and electrical converter to induce a continuing voltage at the input of electrical converter, therefore to create the voltage ripple free. however the DC link condenser is bulkier in size and its life time is full of operative temperature. furthermore value|thevalue|the price} is regarding 5-15% of overall cost of BLDC motor drive. As a trial to scale back the price of motor, DC link condenser is eliminated at the expense of torsion ripple. therefore a brand new torsion ripple compensation technique is planned to make amends for the torsion ripple related to the elimination of the DC link condenser. during this methodology, torsion ripple compensation technique is planned to a star PV array fed DC link condenser free BLDC motor. The static magnet brushless DC (BLDC) motor is utilized to drive a centrifugal pump coupled to its shaft. The BLDC motor is chosen attributable to its deserves [7,9]useful for the event of appropriate water pumping system. This electronically commutated BLDC motor [9-11] is equipped by a voltage supply electrical converter (VSI) that is operated by fundamental shift leading to low shift losses [12-15]. suitability of the planned SPV array fed water pumping system subjected to varied operative and settingal conditions is incontestible by satisfactory simulated results victimization MATLAB/Simulink environment. the present literature exploring SPV array-based BLDC motor-driven pump is predicated on a configuration shown in Fig.1. A dc-dc convertor is employed for MPPT of Associate in Nursing SPV array as was common. 2 section currents ar detected in conjunction with Hall signals feedback for management of BLDC motor, leading to Associate in Nursing enhanced price. the extra management theme causes enhanced price and complexity, that is needed to manage the speed of BLDC motor. Moreover, sometimes a voltage-source electrical converter (VSI) is operated with high-frequency PWM pulses, leading to Associate in Nursing enhanced shift loss and therefore the reduced potency. A DC-DC

buck–boost convertor is used to extract the utmost power obtainable from the SPV array. And he extra functions of buck–boost convertor is soft beginning and speed management of the BLDC motor coupled to pump, by applying the MPPT algorithmic rule befittingly. because of the one switch and least range of reactive parts, this convertor possesses superb conversion potency and offers infinite region for MPPT. This convertor is operated in continuous conductivity mode (CCM) leading to a reduced stress on its power devices and parts. moreover, the shift loss of VSI is reduced by adopting fundamental shift leading to a further power saving and therefore the improved potency. The section currents yet because the DC-link voltage sensors ar utterly eliminated, giving straightforward and economical system while not sacrificing its performance. The speed of BLDC motor is controlled, with none extra management, through the variable DC-link voltage of VSI. Moreover, the soft beginning of BLDC motor is achieved by correct low-level formatting of MPPT algorithmic rule of SPV array.

II. CONFIGURATION OF PROPOSED SYSTEM & OPERATION

Fig. 1 shows the configuration of the proposed SPV-based buck– boost converter fed BLDC motor drive for water pumping. From left to right, the proposed system consists of an SPV array, a buck–boost DC–DC converter, a VSI, a BLDC motor and a water pump. As shown in Fig. 1b, the SPV array generates the electrical energy and feeds the DC–DC buck–boost converter. The insulated gate bipolar transistor (IGBT) switch of the buck–boost converter is operated through an incremental conductance (INC) MPPT algorithm such that the operation of the SPV array is optimized and the BLDC motor has the soft starting. The buck–boost converter is operated in CCM to reduce the stress on the components and semiconductor devices. Furthermore, the buck– boost converter feeds power to the VSI, supplying the BLDC motor coupled to a water pump. Switching sequence for the VSI is provided by the electronic commutation of BLDC motor. An electronic commutation is a process of decoding the Hall Effect signals generated by the inbuilt encoder of the motor according to position of the rotor. The design and control of the proposed system are elaborated in the following sections

III. DESIGN OF THE PROPOSED SYSTEM

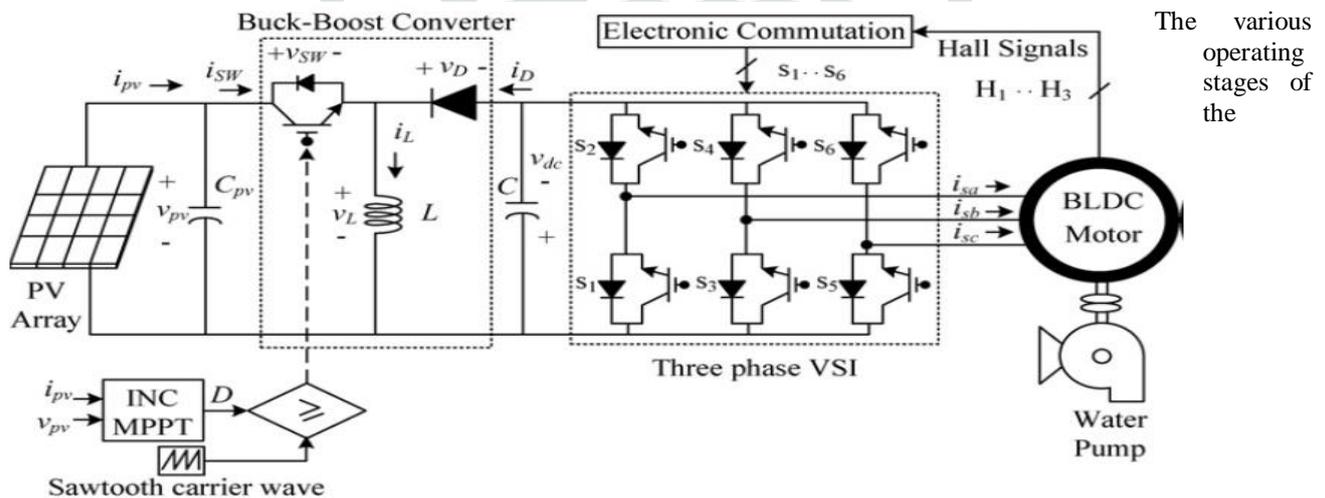


Fig. 1 Configuration of the Proposed SPV array fed BLDC motor driven water pumping system

configuration shown in Fig. 1b such as the SPV array, the buck–boost converter and the water pump are designed such that a satisfactory operation is always accomplished under any kind of change in solar isolation level. A BLDC motor of 1.3 kW rated power is selected and each stage of the proposed system are designed accordingly, as follows.

Design of SPV array

An SPV array of 1.5 kW peak power capacity, somewhat more than required by the motor, is selected so that the performance of the system is not affected by the losses associated with the converters and the motor. The parameters of the SPV array are estimated at the standard solar isolation level of 1000 W/m2. A PV module AP- 100, manufactured by Astro power Inc. [49] with peak power of 100 W, maximum voltage of 16.1 V and maximum current of 6.2 A is considered to design an SPV array of required capacity. First of all, the voltage of the SPV array at MPP is selected in view of the DC voltage rating of the BLDC motor same as DC-link voltage of the VSI. Selecting this voltage as $V_{mpp} = v_{pv} = 241.5$ V, the other parameters are estimated as:

The current at MPP

$$I_{mpp} = i_{pv} = \frac{P_{pv}}{V_{pv}} = 1500/241.5 = 6.2 \text{ A}$$

where $ppv = P_{mpp} = 1500$ W is the peak power capacity.

Numbers of modules connected in series are as

$$N_s = \frac{V_{mpp}}{V_m} = 241.5/16.1 = 15$$

$$N_p = \frac{I_{mpp}}{I_m} = 6.2/6.2 = 1$$

where V_m and I_m are voltage and current of a module at MPP.

The SPV array voltage at MPP, $v_{pv} = V_{mpp} = 241.5$ V appears as the input voltage source, whereas DC-link voltage of VSI, v_{dc} appears as the output voltage of the buck–boost converter. The duty ratio, D of buck–boost converter is estimated, using the input–output relationship as [50]

where $V_{dc} = 310$ V is rated DC-link voltage of VSI on the other hand, neglecting the buck–boost converter losses, an average current flowing through DC link, I_{dc} is as

$$D = \frac{V_{dc}}{V_{dc} + v_{pv}} = \frac{310}{310 + 241.5} = 0.56$$

$$I_{dc} = \frac{P_{mpp}}{V_{dc}} = \frac{1500}{310} = 4.8 \text{ A}$$

An addition of the two currents, i_{pv} and I_{dc} flow through the inductor, L . The inductor, L is estimated as [50]

$$L = \frac{D \times v_{pv}}{f_{sw} \Delta I_L} = \frac{0.56 \times 241.5}{10,000 \times 11 \times 0.4} = 3 \text{ mH}$$

Where f_{sw} is the switching frequency of the buck–boost converter and ΔI_L is an amount of ripple permitted in the inductor current.

TABLE 1
Switching states for electronic commutation of BLDC motor

θ , deg	Hall signals			Switching states					
	H_3	H_2	H_1	S_1	S_2	S_3	S_4	S_5	S_6
NA	0	0	0	0	0	0	0	0	0
0–60	1	0	1	1	0	0	1	0	0
60–120	0	0	1	1	0	0	0	0	1
120–180	0	1	1	0	0	1	0	0	1
180–240	0	1	0	0	1	1	0	0	0
240–300	1	1	0	0	1	0	0	1	0
300–360	1	0	0	0	0	0	1	1	0
NA	1	1	1	0	0	0	0	0	0

As per the estimation in (10), to ensure the satisfactory performance of the BLDC motor-pump, somewhat a higher value of $C = 1500 \mu\text{F}$ is selected.

IV. CLOSED LOOP SPEED CONTROL OF BLDC MOTOR

In the sensed BLDC drive, hall sensors or a shaft encoder is employed to get the rotor position info. The drive system consists of associate outer speed loop for speed management associated an inner current loop for current management. Conventionally 3 separate current sensors area unit} accustomed measure the section currents. however here just one current device is employed, that is placed on the DC link. Speed management The speed management block uses a Proportional Integral (PI) controller. A PI controller tries to correct the error between a measured method variable and desired point by scheming and so outputting a corrective action that may alter the method consequently. The PI controller calculation involves 2 separate modes the proportional mode and therefore the integral mode. The proportional mode verify the reaction to this error, integral mode determines the reaction primarily based recent error. The weighted total of the 2 mode output as corrective action for the management component. The PI controller is wide utilized in the business because of its ease instyle and easy structure.

Here the input to hurry controller is that the speed error. The output of the controller is taken into account as a reference torsion.

A limit is placed on the speed controller output betting on permissible most winding currents

V. MATLAB/SIMULATION RESULTS

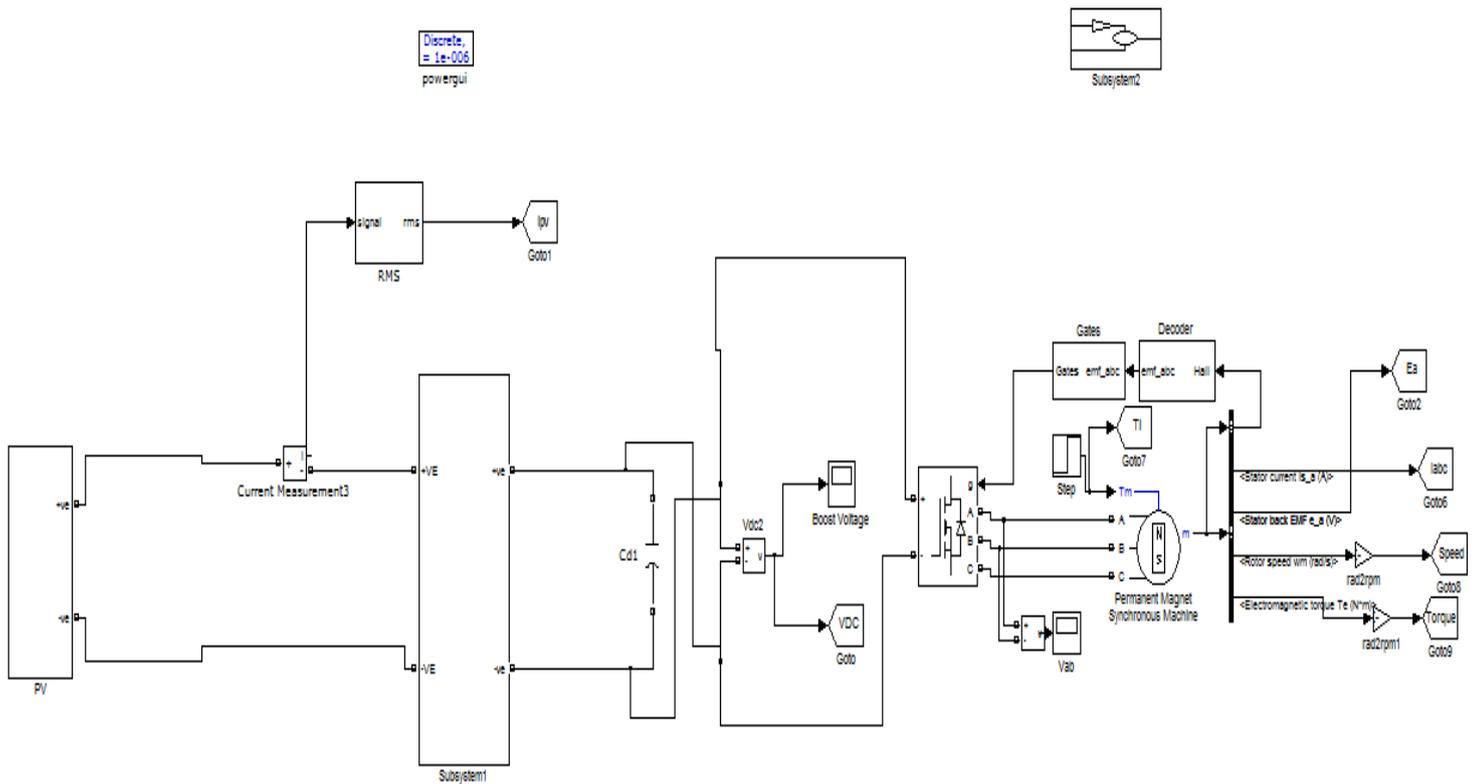
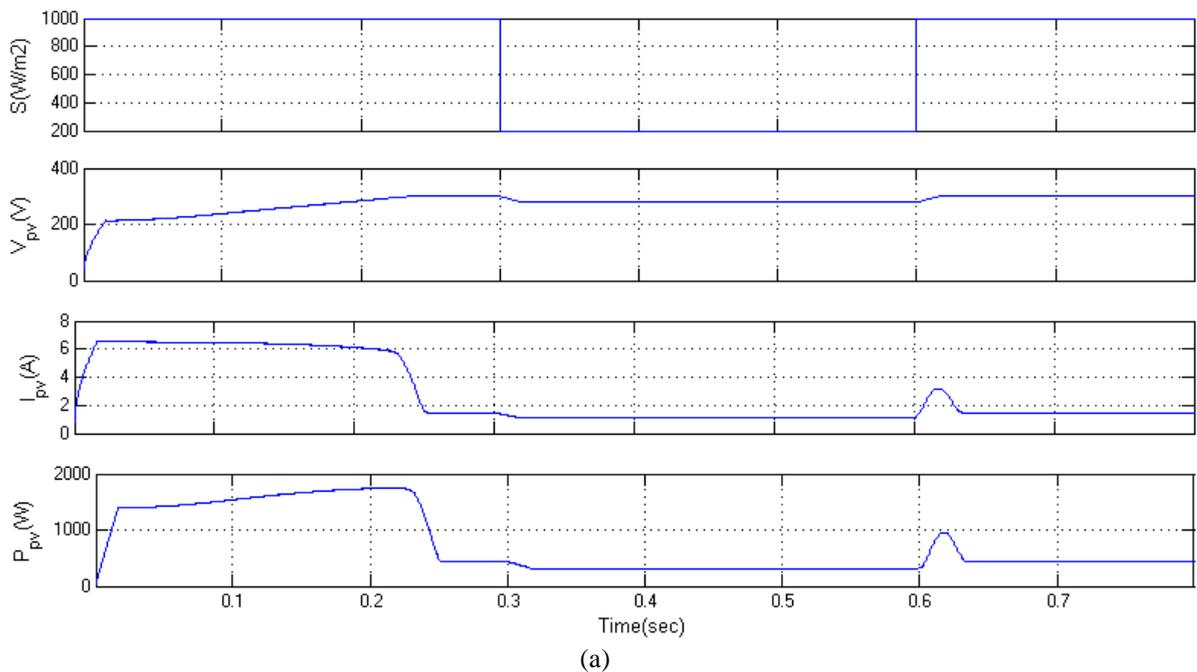
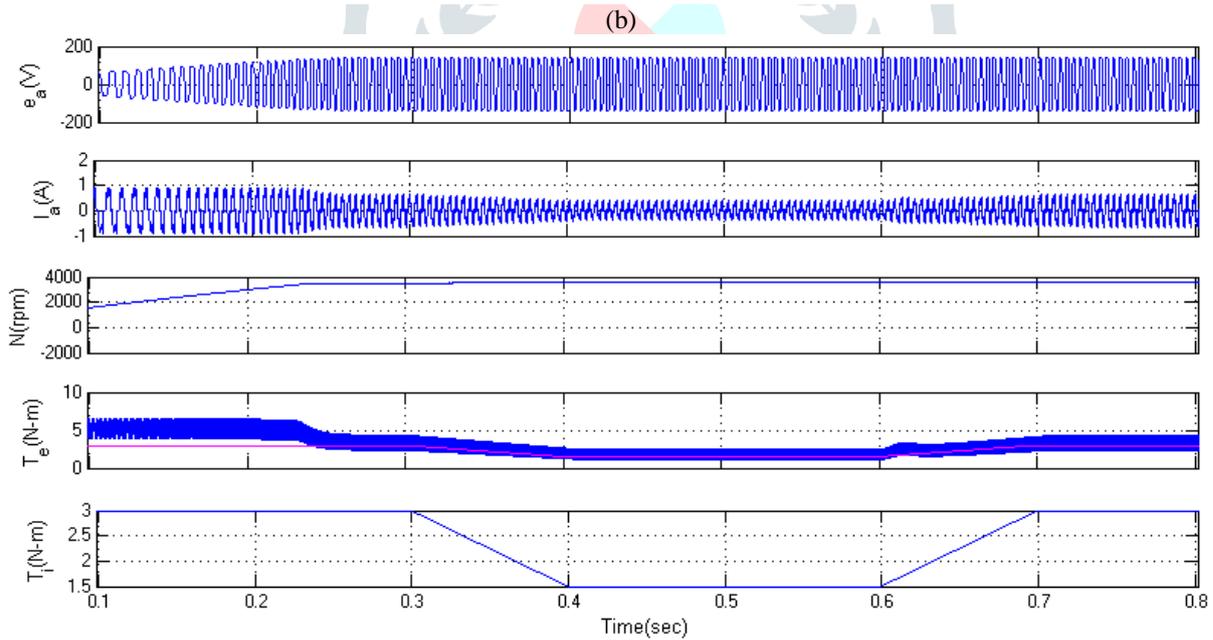
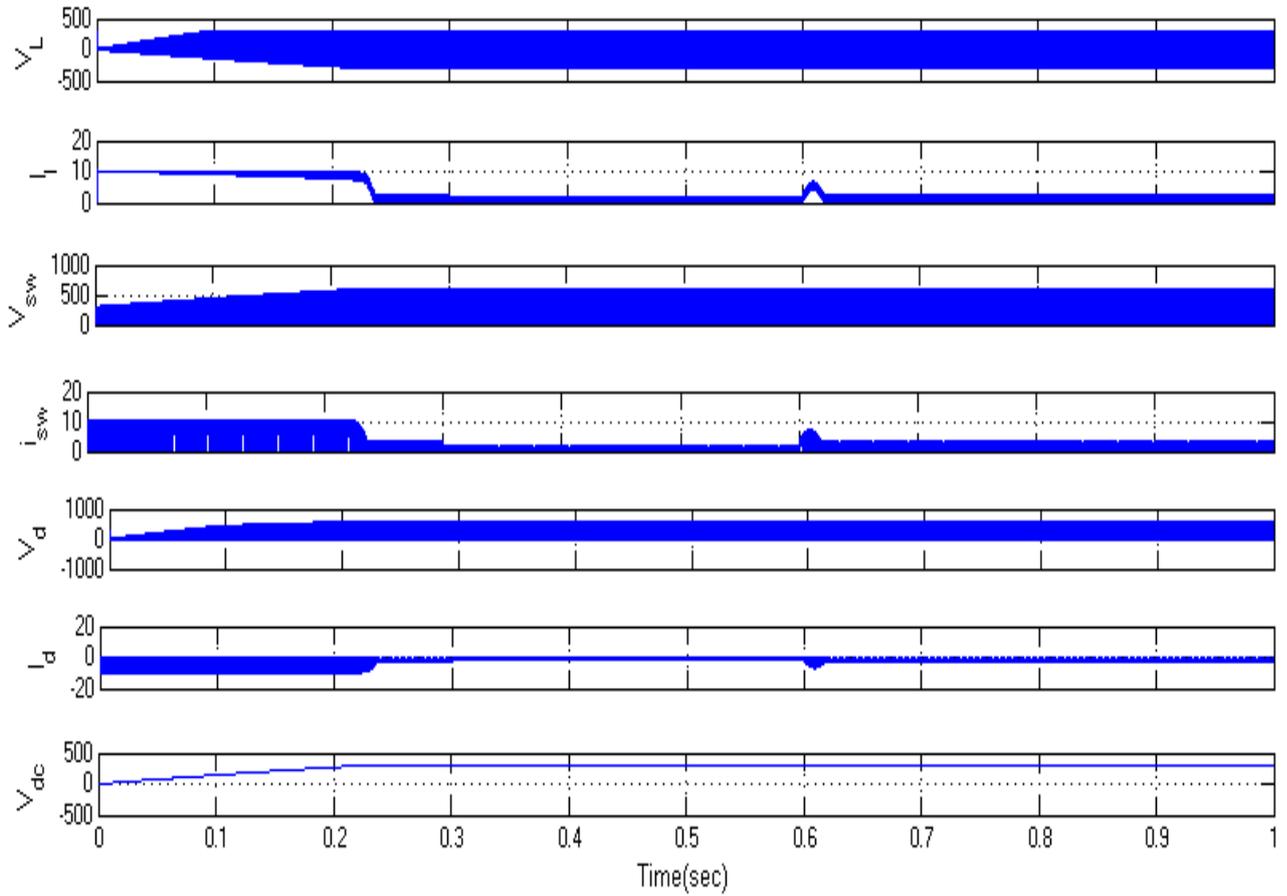


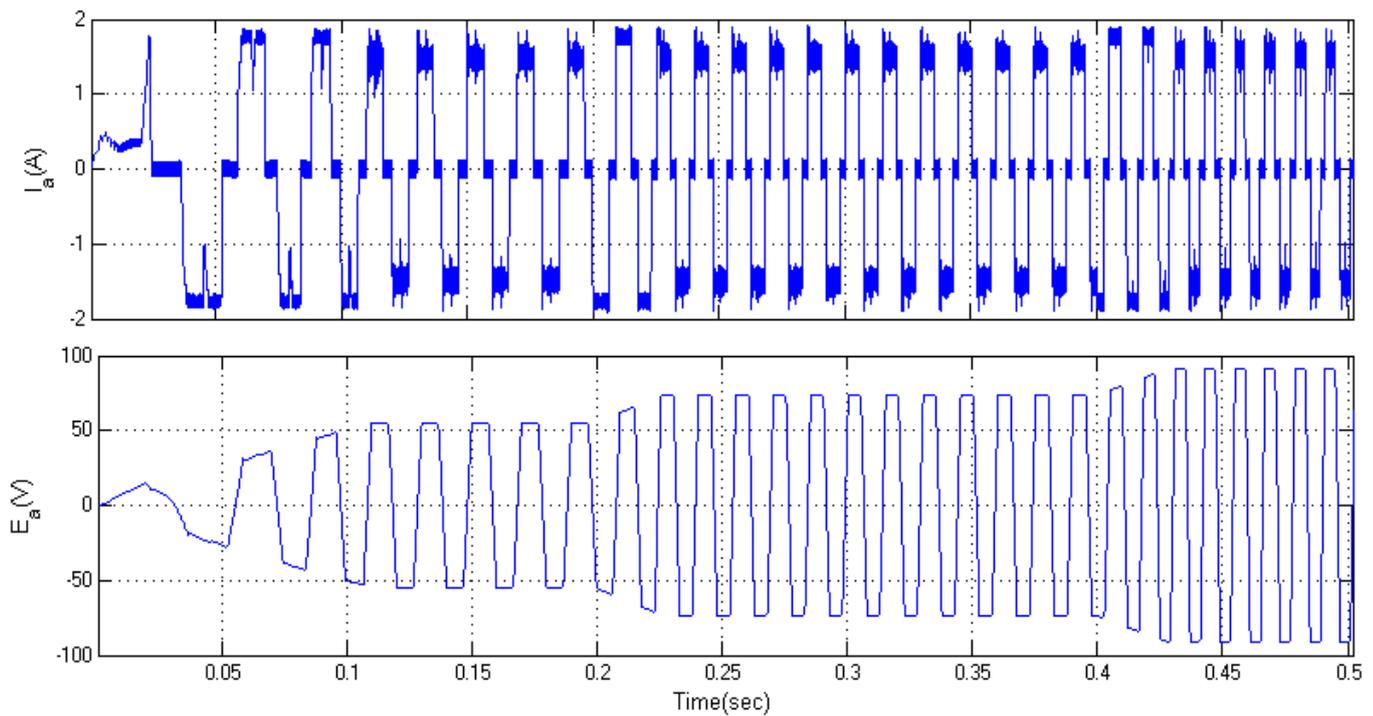
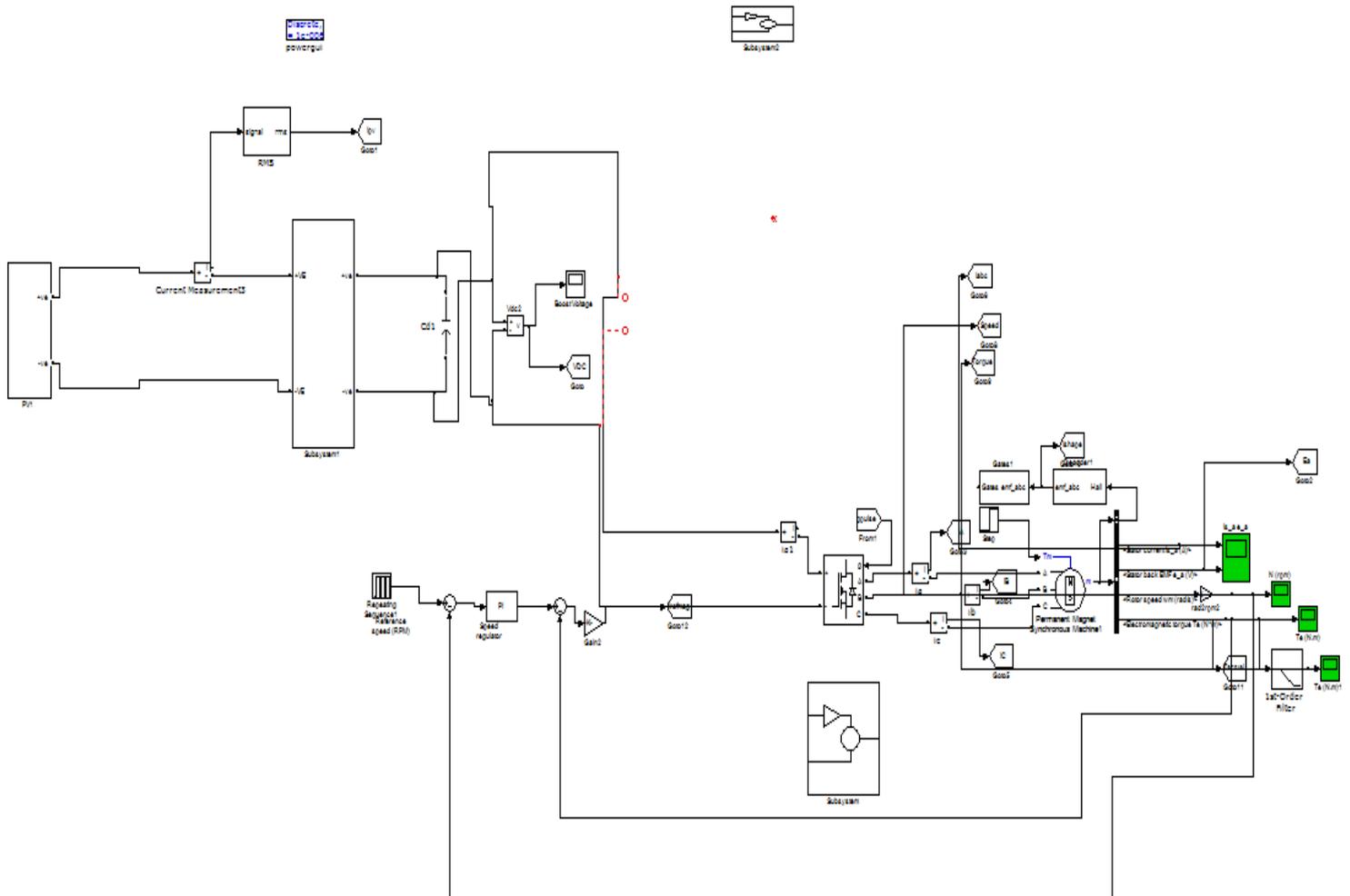
Fig. Matlab/Simulink circuit for Dynamic performance of SPV array-based Buck-Boost converter-fed BLDC motor drive for water pump





(b) drive for water pump. (a) SPV array variables. (b) Buck-Boost converter variables. (c) BLDC motor-pump variables

(c) Dynamic performance of the proposed SPV array-based zeta converter-fed BLDC motor



VI. CONCLUSION

In the sensed BLDC drive, hall sensors or a shaft encoder is employed to get the rotor position info. The drive system consists of associate outer speed loop for speed management associated an inner current loop for current management. Conventionally 3 separate current sensors area unit } accustomed measure the section currents. however here just one current device is

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A limit is placed on the speed controller output betting on permissible most winding currents

REFERENCES

- [1]. Banaei, M.R., Ardi, H., Alizadeh, R., et al.: 'Non-isolated multi-input-single-output DC/DC converter for photovoltaic power generation systems', *IET Power Electron.*, 2014, 7, (11), pp. 2806–2816
- [2]. Singh, B., Shahani, D.T., Verma, A.K.: 'Neural network controlled grid interfaced solar photovoltaic power generation', *IET Power Electron.*, 2014, 7, (3), pp. 614–626
- [3]. Kim, K.-T., Kwon, J.-M., Kwon, B.-H.: 'Parallel operation of photovoltaic power conditioning system modules for large-scale photovoltaic power generation', *IET Power Electron.*, 2014, 7, (2), pp. 406–417
- [4]. Bendib, B., Belmili, H., Krim, F.: 'A survey of the most used MPPT methods: conventional and advanced algorithms applied for photovoltaic systems', *Renew. Sustain. Energy Rev.*, 2015, 45, pp. 637–648
- [5] Subudhi, B., Pradhan, R.: 'A comparative study on maximum power point tracking techniques for photovoltaic power systems', *IEEE Trans. Sustain. Energy*, 2013, 4, (1), pp. 89–98
- [6] de Brito, M.A.G., Galotto, L., Sampaio, L.P., et al.: 'Evaluation of the main MPPT techniques for photovoltaic applications', *IEEE Trans. Ind. Electron.*, 2013, 60, (3), pp. 1156–1167
- [7] Bastidas-Rodriguez, J.D., Franco, E., Petrone, G., et al.: 'Maximum power point tracking architectures for photovoltaic systems in mismatching conditions: a review', *IET Power Electron.*, 2014, 7, (6), pp. 1396–1413
- [8] Tey, K.S., Mekhilef, S.: 'Modified incremental conductance algorithm for photovoltaic system under partial shading conditions and load variation', *IEEE Trans. Ind. Electron.*, 2014, 61, (10), pp. 5384–5392
- [9] Killi, M., Samanta, S.: 'Modified perturb and observe MPPT algorithm for drift avoidance in photovoltaic systems', *IEEE Trans. Ind. Electron.*, 2015, 62, (9), pp. 5549–5559
- [10] Espinoza-Trejo, D.R., Barcenas-Barcenas, E., Campos-Delgado, D.U., et al.: 'Voltage-oriented input-output linearization controller as maximum power point tracking technique for photovoltaic systems', *IEEE Trans. Ind. Electron.*, 2015, 62, (6), pp. 3499–3507
- [11] Faraji, R., Rouholamini, A., Naji, H.R., et al.: 'FPGA-based real time incremental conductance maximum power point tracking controller for photovoltaic systems', *IET Power Electron.*, 2014, 7, (5), pp. 1294–1304
- [12] Renaudineau, H., Donatantonio, F., Font chastagner, J., et al.: 'A PSO-based global MPPT technique for distributed PV power generation', *IEEE Trans. Ind. Electron.*, 2015, 62, (2), pp. 1047–1058
- [13] Sitbon, M., Schacham, S., Kuperman, A.: 'Disturbance observer-based voltage regulation of current-mode boost-converter-interfaced photovoltaic generator', *IEEE Trans. Ind. Electron.*, 2015, 62, (9), pp. 5776–5785
- [14] Dharmaian Retnam, B.B.J., Nanjappa Gounder, A.G., Ammasai Gounden, V.: 'Hybrid power electronic controller for combined operation of constant power and maximum power point tracking for single-phase grid tied photovoltaic systems', *IET Power Electron.*, 2014, 7, (12), pp. 3007–3016
- [15] Aashoor, F.A.O., Robinson, F.V.P.: 'Maximum power point tracking of photovoltaic water pumping system using fuzzy logic controller'. 48th Int. Universities' Power Engineering Conf., 2–5 September 2013, pp. 1–5
- [16] Jiang, Y., Abu Qahouq, J.A.: 'Single-sensor multi-channel maximum power point tracking controller for photovoltaic solar systems', *IET Power Electron.*, 2012, 5, (8), pp. 1581–1592.
- [17] Ouada, M., Meridjet, M.S., Talbi, N.: 'Optimization photovoltaic pumping system based BLDC using fuzzy logic MPPT control'. *Int. Renewable and Sustainable Energy Conf. (IRSEC)*, 7–9 March 2013, pp. 27–31
- [18] Noman, A.M., Addoweesh, K.E., Mashaly, H.M.: 'Simulation and dSPACE hardware implementation of the MPPT techniques using buck boost converter'. *AFRICON*, 9–12 September 2013, pp. 1–9
- [19] Algazar, M.M., AL-monier, H., Abd EL-halim, H., et al.: 'Maximum power point tracking using fuzzy logic control', *Int. J. Electr. Power Energy Syst.*, 2012, 39, (1), pp. 21–28
- [20] El Khateb, A.H., Abd Rahim, N., Selvaraj, J., et al.: 'DC-to-DC converter with low input current ripple for maximum photovoltaic power extraction', *IEEE Trans. Ind. Electron.*, 2015, 62, (4), pp. 2246–2256
- [21] Mamarelis, E., Petrone, G., Spagnuolo, G.: 'Design of a sliding-mode-controlled SEPIC for PV MPPT applications', *IEEE Trans. Ind. Electron.*, 2014, 61, (7), pp. 3387–3398
- [22] Cabal, C., Martínez-Salamero, L., Séguier, L., et al.: 'Maximum power point tracking based on sliding mode control for output-series connected converters in photovoltaic systems', *IET Power Electron.*, 2014, 7, (4), pp. 914–923