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# FOPID Controlled Three Stage Interleaved Boost Converter Fed DC Motor Drive

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**ABSTRACT**

Three stage Interleaved boost converter is a good choice between DC source and DC motor. This work deals with enhancement of response of three stage ILBC fed DC motor drive system using FOPID controller. Closed loop ILBCDCM systems controlled by PI & FOPID are modeled and simulated. The results are presented for PI & FOPID controlled ILBCDCM systems. The comparison of response is done in terms of settling time and steady state error in speed of ILBCDCM. The results indicate that FOPID controlled ILBCDCM gives better response than PI controlled ILBCDCM system.



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## 1. INTRODUCTION

The Renewable energy being the best solution and employed all over the world to satisfy the energy shortage existing without environmental contamination [1]-[3].Among the renewable energies available the most promising energy is Photovoltaic (PV) energy. Though PV system installation cost is high, it has lots of pros, as the system is long lasting and maintenance free [5].

Now-a-days, PV system has grasped the attention of the researchers, but high installation cost and low conversion efficiency are the major drawbacks. To extract maximum power from the PV system MPPT technique can be implemented to the boost converters. By adjusting the duty ratio of the converter, maximum power delivered can be tracked by the PV panel. As the energy generated by the PV system is not sufficient (i.e.) very low voltage. IN order to overcome, the aforementioned cons in the PV system. The DC/DC boost converter is employed in between the power generation stage and the load shown in the Fig.1. The voltage is boosted and high voltage is achieved. But, our conventional power converter has low efficiency due to the poor conversion ratio. The semiconductor devices are used as the switch in the converter. Since, this switch suffers with voltage stress, the switching losses increases and efficiency is decreased [15].

To be employed. In addition to this, the interleaving of converter doubles the voltage gain so that the efficiency can be increased further. Moreover, closed loop control provides better dynamic response and voltage regulation [11]. Novel zero voltage transition PWM converters is given by Lee. To date, soft-switching techniques applied to the PWM converters, with the exception of a few isolated cases, are subjected to either high switch voltage stresses or high switch current stresses, or both. A new class of zero-voltage-transition PWM converters is proposed, where both the transistor and the rectifier operate with zero-voltage switching and are subjected to minimum voltage and current stresses [16]. Family of soft-switching PWM converters with current sharing in switches is presented by Adib [17].

A family of zero-voltage-transition (ZVT) pulse width-modulated converters with synchronous rectifier (SR) is introduced. The SR decreases the conduction losses, while it increases the achieved soft switching range. In this family of converters, zero-voltage-switching (ZVS) condition is attained for the main and rectifier switches. Also, zero-current switching is achieved for the auxiliary switch. In addition, the applied ZVS technique can eliminate the reverse recovery losses of the rectifier switch body diode. Zero-Voltage-Transition PWM Converters With Synchronous Rectifier is suggested by Adib[18].

Analysis and design of a soft-switching boost converter with an HI-bridge auxiliary resonant circuit is given by Park[19]. Sensitivity study of the dynamics of three-phase photovoltaic inverters with an LCL grid filter[20] [21]. Input current ripple cancellation in synchronized, parallel connected critically continuous boost converters is suggested by Elmore[22]-[26]. The above literature does not deal with comparison of responses of PI & FOPID controlled ILBC systems. The work proposes FOPID for the closed loop control of ILBCDCM system.

## 2. SYSTEM DESCRIPTION OF ILBC

Block diagram of existing system is shown in Figure 1. DC from PV is boosted using DC to DC Converter. The output of boost converter is applied to DC load.

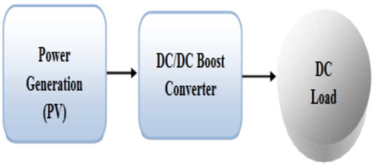


Figure. 1 Block Diagram of Existing System

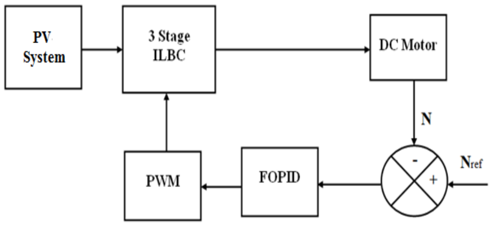


Figure 2. Block Diagram of Proposed TSLBCDCM System

Block diagram of proposed ILBC DCM is shown in Figure 2. Actual speed is sensed and it is compared with the reference speed. The error is applied to a FOPID controller. The output FOPID updates the pulse width applied to ILBC to regulate the output voltage.

*The analysis of FOPID is as follows:*

Over the years, engineers and industrial practitioners have aspired to substitute the traditional PID controller with a more powerful one. However, the PID controller remains the most popular due to its simplicity and clear physical interpretation of the controller parameters. Recently, there has been an extension of the conventional PID controller by substituting the orders of the derivative and integral components to any arbitrary real numbers instead of fixing those orders to one. The fractional order PID (FOPID) controller was first introduced by Podlubny in 1999 [9]. A block diagram that represents the FOPID control structure is shown in Figure 3. The transfer function of an FOPID controller takes the form of. $C_{FOPID}(s)=K_P+K_I/s^{\lambda} + K_D s^{\mu}$

Where $\lambda$ is the order of the integral part, $\mu$ is the order of the derivative part, while $K_p$, $K_I$, and $K_D$ are the constants as in a conventional PID controller.

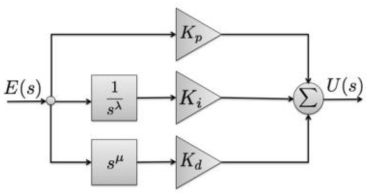


Figure 3. Block Diagram of FOPID Controller

## 3. SIMULATION RESULTS

The open loop ILBCDCM system with step change in input is shown in Figure 3.1. The output of PV is boosted using three stage ILBC. The output of ILBC is applied to DC motor. The input voltage is shown in Figure 3.2 and its value is 170 V. The motor speed is shown in Figure 3.3 and its value is 1300RPM. The Torque response is shown in Figure 3.4 and its value is 3 N-m. Higher starting torque is due to the high starting current.

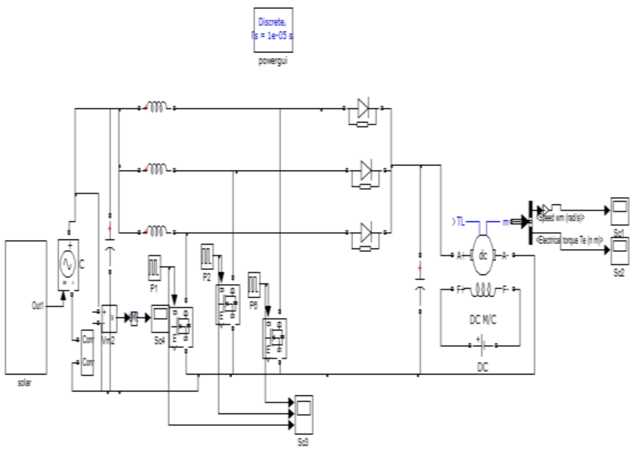

Figure 3.1 Open Loop ILBCDCM System with Step Change in Input

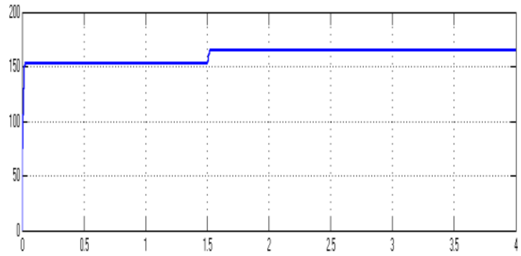

Figure 3.2 Input Voltage

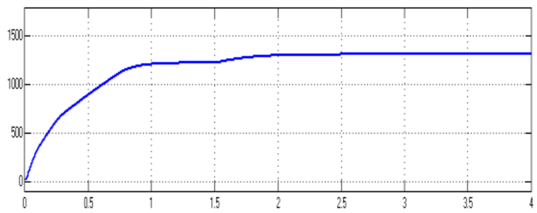

Figure 3.3 Motor Speed

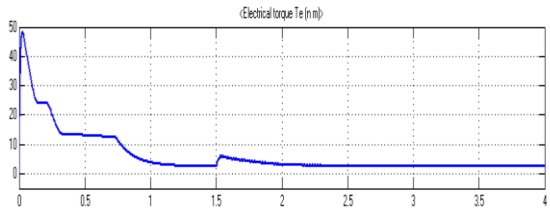


Figure 3.4 Torque Response

Closed loop ILBCDCM system with PI controller is shown in Fig 4.1. Actual speed of DCM is sensed and it is compared with the reference speed. The speed error is applied to a PI controller. The output of PI controller is compared with three repeating sequences displaced by 120°. The outputs of comparators are applied to the switches of TSILBC. The input voltage is shown in Fig 4.2 and its value is 170 V. The motor speed is shown in Fig 4.3 and its value is 1000 RPM. The Torque response is shown in Fig 4.4 and its value is 1 N-m.

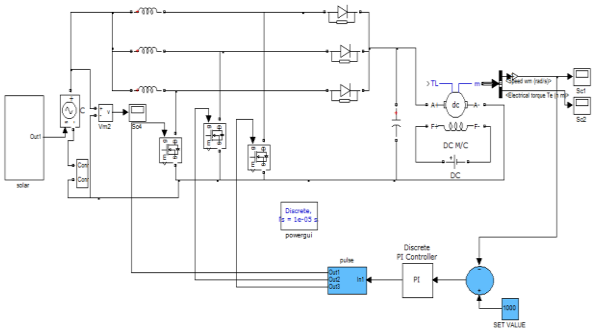

Figure 4.1 Closed Loop ILBCDCM System with PI Controller

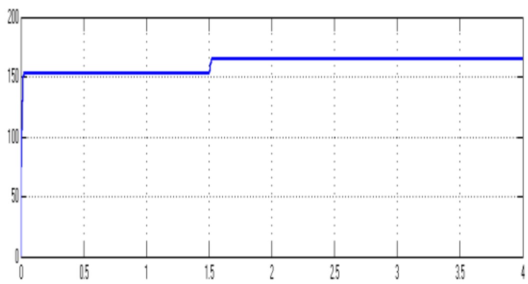

Figure 4.2 Input Voltage

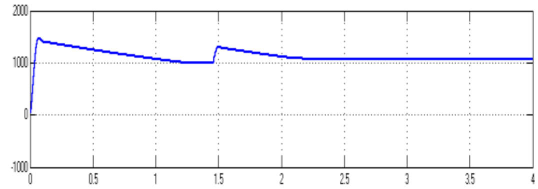

Figure 4.3 Motor speed

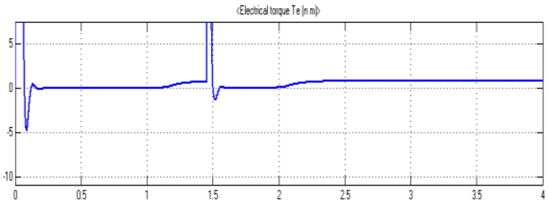


Figure 4.4 Torque

Closed loop ILBCDCM system with FOPID controller is shown in Figure 5.1. The PI controller is replaced by FOPID controller. The input voltage is shown in Figure 5.2 and its value is 170 V. The motor speed is shown in Figure 5.3 and its value is 1000RPM. The torque developed is shown in Figure 5.4 and its value is 1N-m. The summary of time domain parameters is given in Table-1. Rise time is reduced from 1.52 to 1.51 sec. Settling time is reduced from 2.4 to 1.6 sec. Peak time is reduced from 1.7 to 1.53 sec. The steady state error is reduced from 2.7 to 1.3 V. It can be seen that the response with FOPID is faster than that of PI controlled system.

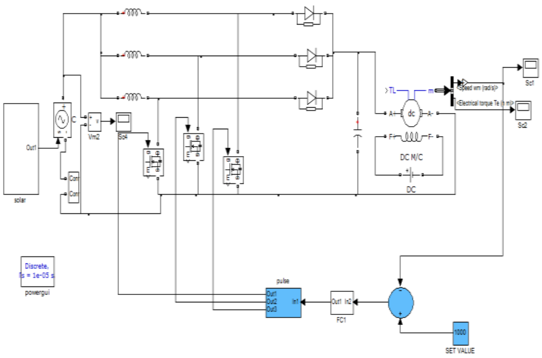


Figure 5.1 Closed Loop ILBCDCM with FOPID Controller

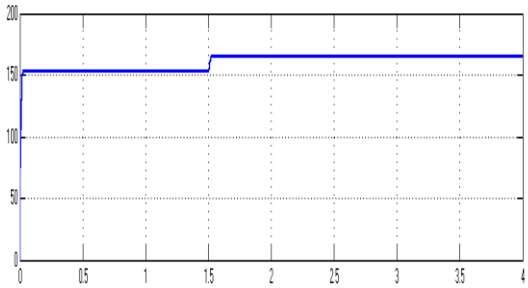

Figure 5.2 Input Voltage

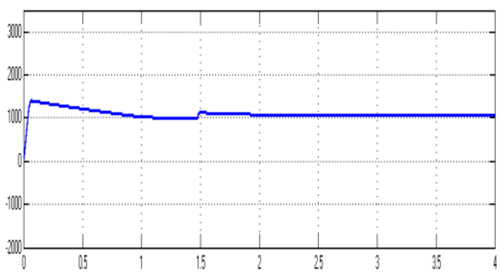

Figure 5.3 Motor Speed

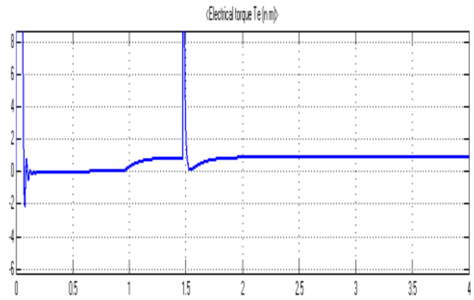


Figure 5.4 Torque Developed

Table 1. Summary of Time Domain Parameters

| Controllers | $t_r$ | $t_s$ | $t_p$ | $E_{ss}$ |
|---|---|---|---|---|
| **PI** | 1.52 | 2.4 | 1.7 | 2.7 |
| **FOPID** | 1.51 | 1.6 | 1.53 | 1.3 |

## 4. CONCLUSION

Closed loop controlled ILBCDCM systems with PI and FOPID are modeled and simulated successfully. The results of comparison indicate that setting time is as low as 1.6 secs and steady mate error is 1.3V with FOPID controller. Therefore FOPID controlled ILBCDCM has better dynamic response than other systems. The proposed system has advantages like reduced current ripple and improved response. The disadvantages of ILBCDCM are increased inertia and cost.The Scope of the present work is to compare the responses of PI & FOPID controlled ILBCDCM systems. The comparison between PI & PR controlled systems will be in future.

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