FRACTIONAL ORDER PID BASED CURRENT MODE CONTROLLED REBOOST CASCADED 7-LEVEL 3-Φ INVERTER FED INDUCTION MOTOR SYSTEM WITH SUPERIOR RETORT

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Abstract

This effort recommends PV based 3-Φ (Multi Level Inverter) MLI with 3Phase induction motor (PVTPMLITPIM) using PI & Fractional Order PID (FOPID) controller closed loop system’. These exertions intend Re Boost Converter (RBC) between PV and MLI, also intended FOPID for control of PVTPMLITPIM system. “PI & FOPID controlled frame works” are composed & recreated utilizing MATLAB. The standards of operation & simulation comes about are observed. The simulation consequences of PI & FOPID controlled PVTPMLITPIM frameworks are evaluated in terms of time domain parameters & association table were analyzed and exhibited. The outcomes show FOPID controlled PVTPMLITPIM system is speedier than that of PI controlled PVTPMLITPIM system.

Keywords: Multi Level Inverter, Re Boost Converter, simulation

I. Introduction

Ongoing days, the Distribution Generation (DG) assumes an imperative job in remote territories to procure the power request by using RES where the utility framework is non nearness. Sustainable power sources have massive improvement because of expanded energy request, clean energy, and diminished petroleum products. A few energy sources like sunlight based, energy component and wind...
energy conversion systems (WECS) are interfaced to network/load by using force molding units. In that power molding units, DCAC inverter topology assumes a urgent job in present day setup of DG plan and furthermore utilized in numerous mid voltage high power run applications.

Pedra[1] presented correlation of isolated models for VSI nourished customizable speed drive during voltage hangs when the duringoccasion proceed with method of activity is dynamic. To check whether contrasts in the improved models stay little, broad scopes of sags are recreated, and drive affectability to list type and profundity is outlined.

"-Grid to independent-transition-motion-sensor less double-inverter control of - PMSG with unbalanced-grid-voltage lists & harmonics-sifting" were exhibited. The grid side inverter control framework utilized PI current controllers with cross coupling, decoupling and line voltage feed forward disturbance compensation [II]. Single stage input variable speed ac engine framework dependent on an electrolytic capacitor less solitary stage 3-Φ Inverter was given by Zhou[III]. Similar dependability investigation of 3 fundamental MLI's utilizing 2 different methodologies was displayed. This exertion exhibited an exhaustive dependability assessment of central MLI. Re Boost converter with 7 level 3 PInverter engine is delineated in Fig1. PV and reboost converter 3Φ configuration exhibited here.

The dependability of the MLI is broke down by figuring the interim to malfunction for each component[IV]. The count was carried out by 2 strategies (estimated and precise) to accomplish better correlations. "Upgraded displaying and control procedure of the solitary stage photovoltaic grids associated fell HbridgeMLI" was recommended by Kim[V]. This effort presents the displaying and controlloopplan strategy with a reversed decoupling plan of a solitary PV grid connected 5 level fell-HbridgeMLI.

"An outline of different gridsynchronization methods for singlestage framework mix of sustainable conveyed powergenerationframeworks" was exhibited by Behra[VI]. Because of the expanding entrance of singlestageDG's into the utilitygrid the necessitate of an improved and productive controller to control the disseminated

![Fig1. Block Diagram of Reboost converter with 7level 3-Φ inverter & IM](image)
Power creating frameworks is additionally expanding. Hence the gridsynchronization methods assume a significant job so as to keep up the matrix necessities as far as power quality and recurrence of the network voltage.

Power and voltage control for single stage fell H-connection MLC under lopsided loads[VII] was presented. A power based d-connection voltage equalization control is likewise proposed for unequal burden conditions. The new control strategy is structured in a virtual $\alpha\beta$ stationary reference outline without coordinate change to keep away from the potential issues identified with computational unpredictability.

"Smartgrid association of an IM utilizing a 3-stage gliding H-bridge framework as a seriescompensator" was proposed by Leng. -The-framework uses an arrangement of 3-Φ floating-capacitor H-bridge converters situated in each-stage between the utility-grid & a squirrel-confine-induction-engine. Infusing-series voltage with every stage, the projected framework can control the voltage provided to an engine, expanding the resistance of grid voltage sags[VIII]. This exertion goes for an electric vehicle furnished with OWPMSM drive framework with double power sources and double inverters; in light of examining the outer qualities of each winding mode, proposed exchanging methodology whose torque immersion and judgmental calculation, which is uncaring toward engine's parameters, might consequently acknowledge up exchanging of the winding mode[IX].

"Shortcoming tolerant multilevel topology dependent on 3phase HBI for openend winding IMD" was recommended by Silva[X]. In this, a MLI dependent on 3phase HBI for an openend winding IMD was displayed and its adaptation to internal failure capacity was examined. The staggered topology was acquired utilizing 3WYE associated 3phase HBI to supply openend winding IM.

Elevated boost DC-DC converter premeditated and compared performances (HS-LC) conversion circuit was evaluated composing of 1 switch, 2 inductors, 2 capacitors, and 6 diodes. Theoretical comparison shows that compensate of privileged conversion gain, lower switching stress, and lower inductor current ripple.[XI]

II. Research Gap

The exceeding writing does not deal with PV fed TPMLI TPIM system. This work proposes TPMLI for the control of IM system. Closed loop control of PVTPMLITPIM using FOPID is not present in the abovementioned literature. Hence, FOPID logic is proposed for the control of PVTPMLITPIM system. The proposed work compares the PI and FOPID-controlled TPMLITPIM systems.

III. Proposed System

Block diagram of closed loop RBC with 7-level 3Pinverter with PI/FOPID controller is appeared in Fig 2. The yields of the PI/FOPID are gives current reference. This is evaluated with actual motor current & error is applied to PI/FOPID controller to get updated pulses for RBC. Equations are as follows:
\[ V_0 = \frac{V_s}{1-a} \]  \hspace{1cm} (1)

Efficiency of the reboost converter to calculate the output current is

\[ \eta = \frac{V_{oa}}{V_{1a}} \]  \hspace{1cm} (2)

**Figure 2.** Block diagram of closed loop RBC with 7 level 3 Pinverter with PI/FOPID controller

The values of L & C are calculated by assuming \( \Delta I \) & \( \Delta V \) are

\[ \Delta V = \frac{V_D}{fL} \]  \hspace{1cm} (3)

\[ \Delta I = \frac{I_D}{fC} \]  \hspace{1cm} (4)

The transfer function of FOPID is

\[ TF_1 = K_1 + K_2/S^p + K_3S^q \]  \hspace{1cm} (5)

**IV. Results and discussion**

'Circuit diagram of open loop Reboost converter with TPMLI-TPIM and source disturbance' is appeared in Fig 3. Voltage across PV of RBC-TPMLITPIM is delineated in Fig 4 and its value is 60 volts. Voltage across motor load of RBC-TPMLITPIM is delineated in Fig 5 and its value is 499 volts. Motor speed of RBC-TPMLITPIM is delineated in Fig 6 and its value is 2000 RPM. Motor Torque of RBC-TPMLITPIM is appeared in Fig 7 and its value is 0.90 Nm.
Figure 3 Circuit diagram of open-loop Re boost converter with TPMLITPIM and source disturbance

Figure 4 Voltage across PV of RBCTPMLITPIM

Figure 5 Voltage across motor load of RBCTPMLITPIM
Circuit diagram of closed loop-RBC-7level-TPMLI-TPIM with PI controller is delineated in Fig 8. Voltage across PV of RBC-TPMLITPIM with PI controller is appeared in Fig 9 & its value is 60 Volts. Voltage across RL load of RBC-TPMLITPIM with PI controller is delineated in Fig 10 & its value is 499 Volts. Motor speed of RBCTPMLITPIM with PI controller is delineated in Fig 11 & its value is 1800 RPM. Motor Torque of RBCTPMLITPIM with PI controller is delineated in Fig 12 & its value is 11 Nm.

Figure 8 Circuit diagram of closed loop RBC7 level TPMLITPIM with PI controller
Figure 9 Voltage across PV of RBC TPMLITPIM with PI controller

Figure 10 Voltage across RL load of RBC TPMLITPIM with PI controller

Figure 11 Motor speed of RBC-TPMLITPIM with PI controller

Figure 12 Motor Torque of RBC-TPMLITPIM with PI controller

Circuit diagram of closed loop RBC7 level TPMLITPIM with FOPID controller is delineated in Fig13. Voltage across PV of RBC-TPMLITPIM with FOPID controller is appeared in Fig14 & its value is 60 volts. Voltage across RL load of RBC-TPMLITPIM with FOPID controller is delineated in Fig15 & its value is 499 Volts. Motor speed of RBC-TPMLITPIM with FOPID controller is delineated in Fig16 & its value is 1800 RPM. Motor Torque of RBC-TPMLITPIM with FOPID controller is delineated in Fig17 & its value is 11 Nm.
Figure 13 Circuit diagram of closed loop RBC7level TPMLITPIM with FOPID controller

Figure 14 Voltage across PV of RBC-TPMLITPIM with FOPID controller

Figure 15 Voltage across RL load of RBC-TPMLITPIM with FOPID controller
Comparison of Timedomain Parameters for motor speed using PI and FOPID controllers is given in Table 1. By using FOPID, the– risetime is diminished from 6.029 Sec to 6.025 Sec; the– peaktime is diminished from 7.83 Sec to 7.15 Sec; the– settlingtime is diminished from 8.53 Sec to 7.92 Sec; the-steady-state-error-in speed is diminished from 1.3 RPM to 1.1 RPM. Bar Chart Comparison of Time domain Parameters for motor speed is delineated in Fig 18.

Table 1 Comparison of Time domain Parameters for motor speed

| Controller | $T_r$(Sec) | $T_s$(Sec) | $T_p$(Sec) | $E_{ss}$(RPM) |
|------------|------------|------------|------------|---------------|
| PI         | 6.029      | 8.53       | 7.83       | 1.3           |
| FOPID      | 6.025      | 7.92       | 7.15       | 1.1           |
“Comparison of Timedomain Parameters for motor Torque using PI and FOPID controllers” is given in Table 2. By using FOPID, the–risetime is diminished from 6.017 Sec to 6.015 Sec; the–peakt ime is diminished from 7.75 Sec to 7.68 Sec; the–settlingtime is diminished from 8.48 Sec to 7.90 Sec; the–steadystateerror is diminished from 0.9 Nm to 0.7 Nm. Bar Chart Comparison of Time domain Parameters for motor Torque is delineated in Fig 19. The timeresponse with FOPID is faster than that of PI controlled RBC TPMLITPIM system.

### Table 2

| Controller | $T_r$(Sec) | $T_s$(Sec) | $T_p$(Sec) | $E_{ss}$(Nm) |
|------------|------------|------------|------------|-------------|
| PI         | 6.017      | 8.48       | 7.75       | 0.9         |
| FOPID      | 6.015      | 7.90       | 7.68       | 0.7         |

![Figure 19.Bar Chart Comparison of Time domain Parameters for motor Torque](image)

**V. Experimental results**

“-Hardware for ReBoost converter with 7level-MLI” is tested. The hardware consists of ‘solar-panel’, ‘rectifierboard’, ‘inverterboard’, controlboard, transformer and reboost board. -The-input-voltage of RBC-with 7levelMLI is appeared in Fig20. -The-Output voltage of RBC with 7levelMLI is appeared in Fig21. The-Switching pulses for M1 &M3 of RBC with 7levelMLI is appeared in Fig22. The-Switching pulses for M5 &M7 of RBC with 7levelMLI is appeared in Fig23. The-Output-voltage of MLI is appeared in Fig24.Current through motorload is delineated in Fig.25.
Fig 20 Input voltage

Fig 21 Switching pulse of Re boost converter (M1, M2)

Fig 22 Voltage across Reboost converter

Fig 23 Switching pulse of multilevel inverter (S1, S3)
VI. Conclusion

The PI & FOPID controlled PV fed RBCTPMLITPIM frameworks is efficaciously demonstrated and simulated. The case studies with PI and FOPID controllers are exhibited in detail. It can be noticed that the settling time is abridged from 8.48 to 7.9 seconds and the steadystate error is abridged from 0.9 to 0.7 Nm by replacing the PI controller with FOPID controller. The results indicate that the FOPID based RBCTPMLITPIM system gives the best dynamic response. The benefits of the suggested system are highvoltage gain & reduced steady state error. The disadvantage of the recommended system is that it’s appropriate for lowpower loads. The hardware for RBCTPMLITPIM is fabricated and tested. The hardware results match with simulation ones of RBCTPMLITPIM.

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The scope of the current work is the comparison of FOPID Logic and PI controlled closed loop RBCTPMLITPIM systems. The comparison of Artificial NeuralNetwork (ANN) and Fuzzy based RBCTPMLITPIM systems could be done in the future. The hardware may be implemented using FPGA to enhance the switching frequency level of RBC.

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