

Closed Loop Controlled IDVR for Eight bus system using PID Controller

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Abstract

This work deals with comparison of responses of PI and PID controlled IDVR systems for eight bus systems. IDVR is a good interface between strong and weak systems. Voltage of strong system is sensed, it is rectified and inverted. The output of inverter is injected to the second line to compensate the voltage sag due to addition of extra load. Simulink models for PI and PID and controlled systems are developed and they are used for simulation studies. Simulation results for bus voltage, real power and reactive power are presented. The results of PI & PID controlled system are compared in terms of time domain parameters. The comparison indicates that PID controlled IDVR system has faster response than PI controlled system.

I. Introduction

Harmonic resonance system to traction power-supply system using train model in china high-speed railway is given by Zhang [1]. Traction system unbalance analysis methodologies are presented by Chen [2]. In introduction to next-generation railway power systems and their operation is suggested by Fuente [3]. Control of utility system unbalance caused by single-phase electric traction is given by Kneschke [4]. A multi-purpose balanced transformer for railway traction applications is presented by Kang [5]. A feeding transformer for railway AC traction system is suggested by Morimoto [6]. Power flow analysis and future development study for an AC electric railway is given by Raygani [7]. Advanced co-phase traction power supply system based on three-phase to single-phase converter is presented by Shu [8].

A half-bridge winding compensation based power conversion system for electric railway with LQRI is suggested by Zhang [9]. Unbalance compensation using direct power control for electric railway systems is given by Bueno [10]. Electronic frequency converter feeding single-phase circuit and controlling feeder voltage with fixed power factor method for shinkansen is presented by Kunomura [11]. Hybrid active filter for harmonically unbalanced three phase three wire railway traction loads is suggested by Senini [12]. Optimal impedance termination of 25-KV electrified railway systems for improved power quality is given by Holmes [13]. Reactive power compensation in railways based on AC boost choppers is presented by

Raimondo [14]. Chopper-controlled steinmetz circuit for voltage balancing in railway substations is suggested by Ladoux [15]. Optimization-based voltage support in traction networks using active converters is given by Bahrani[16]. Railway static power conditioners for high-speed train traction power supply systems using three-phase transformers is presented by Luo[17]. Digital detection, and distribution system for co-phase traction power supply is suggested by Zhao [18]. Voltage Fluctuation Compensator for Shinkansen is presented by Uzuka [19]. Verification of railway static power conditioner in Tohoku Shinkansen on actual operation is given by Masataroi [20]. Hybrid power quality compensator with minimum DC operation voltage design for high-speed traction power systems is presented by Wong [21].

A control technique for three-phase shunt hybrid power filter is suggested by Rahmani [22]. Parallel-connected shunt hybrid active power filters working at different switching frequencies for improved performance is given by Bhattacharya [23]. An inductively active filtering method for power-quality enhancement of distribution networks with nonlinear loads is presented by Krause [24]. Optimal multi objective design of hybrid active power filters considering a distorted environment is suggested by Zobaa[25].

A modified three-phase four-Wire UPQC topology with reduced DC-link voltage rating is given by Karanki [26]. Hybrid multi converter conditioner circuit for high-power applications is presented by Cadaval [27]. Recent advances and industrial applications of multilevel converters is suggested by Malinowski [28]. A medium-voltage ac/dc power conversion system consisting of a diode rectifier and a shunt active filter is given by Srianthumrong [29]. Adaptive DC-Link voltage-controlled hybrid active power filters for reactive power compensation is presented Han [30].

Theory and applications of multilevel converter is suggested by Richardeau [31]. Long-term reliability of railway power inverters cooled by heat-pipe-based systems is given by Vellvechi[32]. PWM inverters using IGBTs is presented by Casanellas [33]. Experimental evaluation of IGBTs for characterizing and modeling conducted EMI emission in PWM inverters is suggested by Liu [34]. The above literature does not deal with comparison of PI & PID controlled IDVR system. This work compares the dynamic response of PI & PID controlled IDVR systems. The comparison is done in terms of time parameters.

II. Simulation Results

Closed loop with eight bus system with PI controller is shown in Fig 3.1. The voltage of line is sensed and it is compared with reference voltage. The error in voltage is applied to a PI controller[42-45]. The output of PI is given to two comparators to produce updated pulses to the IGBTs of rectifier. The output voltage is shown in Fig 3.2 and its peak value is 4000V. The RMS output voltage is shown in Fig 3.3 and its value is 2600V. The real and reactive powers are shown in Fig 3.4 and its value of real power $5.8 \times 10^4 \text{W}$ and reactive power is $3.6 \times 10^4 \text{VAR}$.

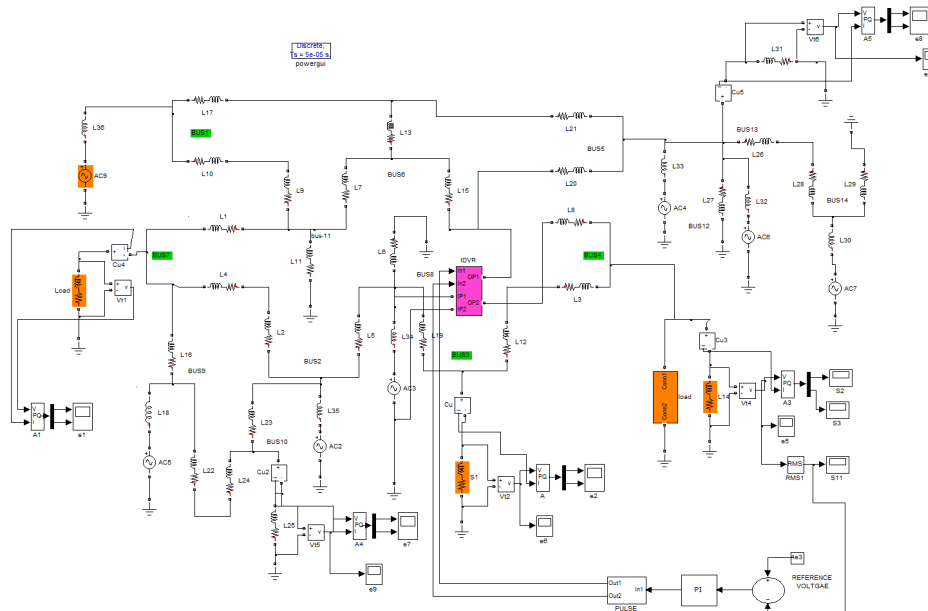


Fig 3.1 Closed Loop System with PI Controller

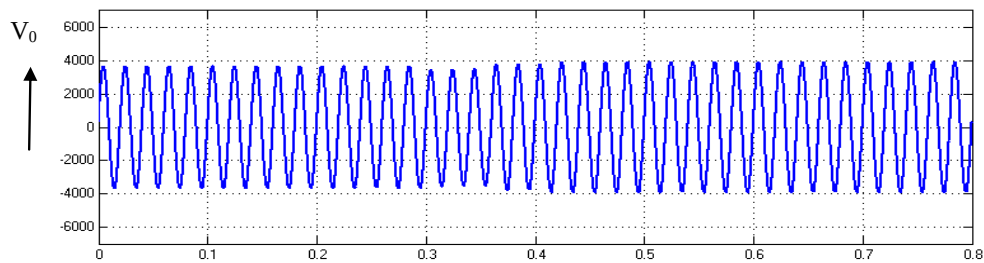


Fig 3.2 Output Voltage → Time

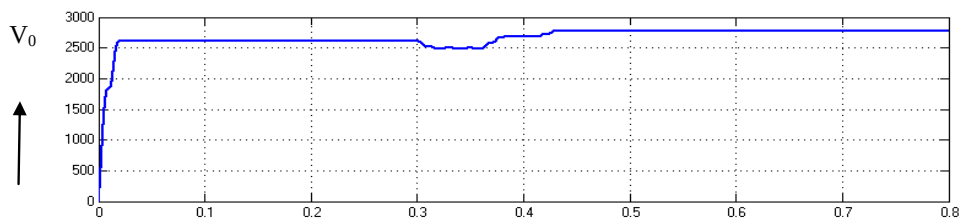


Fig 3.3 RMS Output Voltage → Time

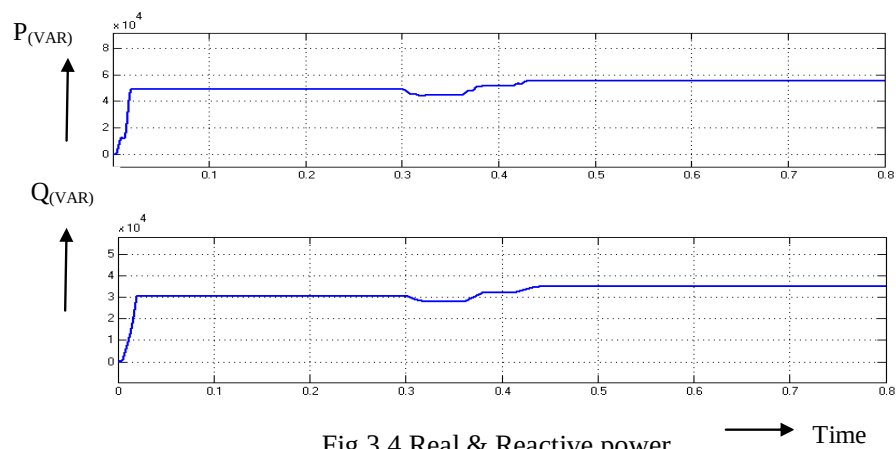


Fig 3.4 Real & Reactive power → Time

Closed loop with eight bus system PID controller is shown in Fig 4.1. The PI controller of previous system is replaced by PID controller. The output voltage is shown in Fig 4.2 and its peak value is 4000V. The RMS output voltage is shown in Fig 4.3 and its value 2600V. The real and reactive are shown in Fig 4.4 and its value is $5.8 \times 10^4 \text{W}$, Reactive power is $3.6 \times 10^4 \text{VAR}$. The comparison of time domain parameters is shown in Table-1. It can be seen that the response with PID is faster than that of PI controlled system[35-38].

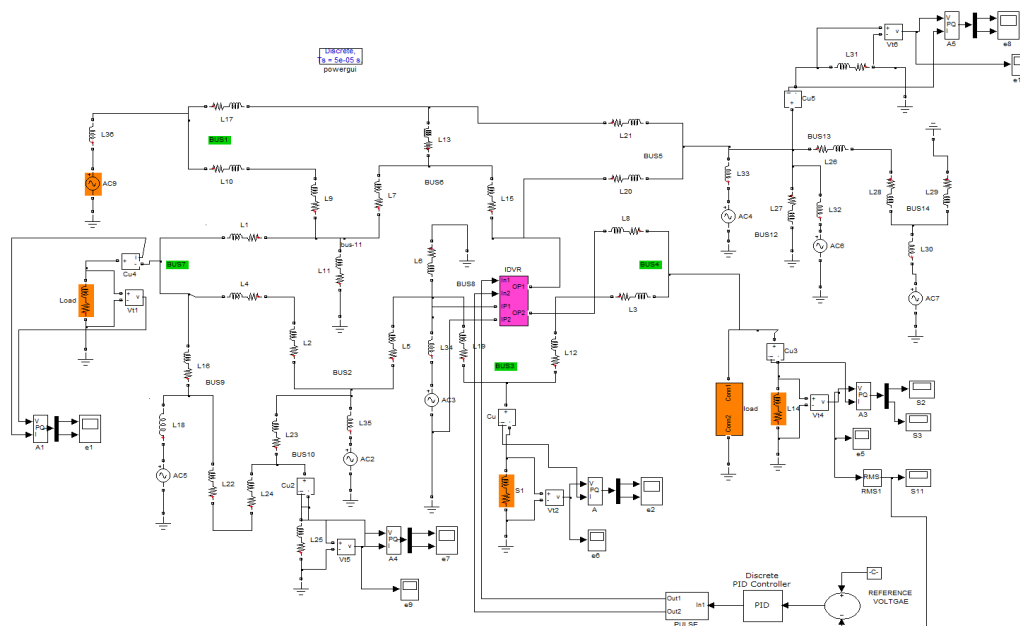


Fig 4.1 Closed Loop Systems with PID Controller

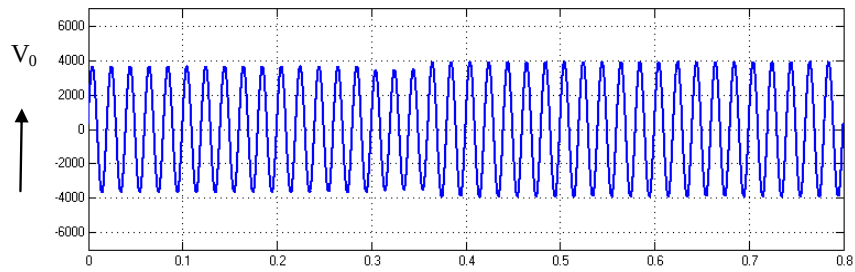


Fig 4.2 Output Voltage

Time

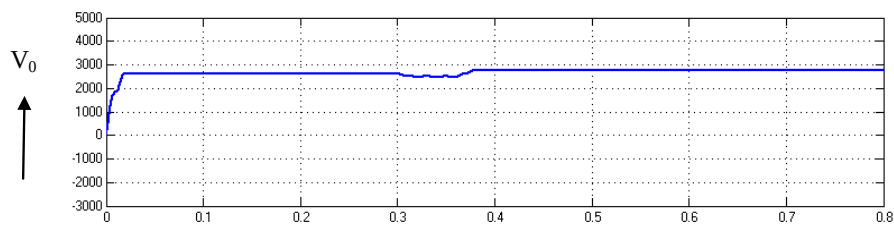


Fig 4.3 RMS Output Voltage

Time

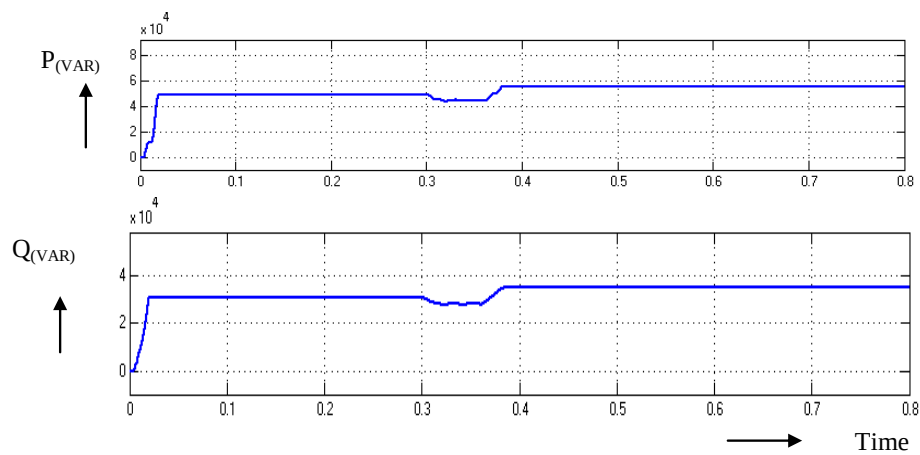


Fig 4.4 Real & Reactive Power

Time

Table-1 Comparison of Time Domain Parameters

Controllers	T_r	T_s	T_p	E_{ss}
PI	0.33	0.36	0.42	4.53
PID	0.32	0.34	0.37	3.65

Comparison of responses with PI and PID controlled IDVR system is given in Table-1. Rise time is reduced from 0.33 to 0.32 Sec[39-43], Settling time is reduced from 0.5 to 0.43 Sec, peak time is reduced from 0.36 to 0.34 Secs and steady state error is reduced from 4.53 to 3.65 Volts.

III. Conclusion

Closed loop controlled IDVR systems with PI and PID are modeled and simulated successfully. The summary of responses indicates that the settling time is reduced from 0.36 to 0.34secs. The steady state error is reduced from 4.53 to 3.65V. Thus the response of PID controlled IDVR system is better than that of PI controlled system. The Advantage of proposed system is voltage sag comparison and fast response. The Disadvantage of the IDVR is that it needs driver circuit for rectifier and inverter.

The present work deals with comparison of responses with PI and PID controllers. The comparison between PI and FLC based IDVR system will be done in Future.

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