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Improvement of Dynamic Response Using Fuzzy Logic Controlled Buck Boost Converter Inverter Based Solar System

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Abstract: This Work deals with design, modeling and simulation of the buck boost converter inverter based fuzzy logic controlled solar system. Two buck boost converters are cascaded in parallel to reduce the ripple in the DC output. The DC from the solar cell is stepped up using boost converter. The output of the boost converter is converted to 50Hz AC using a single phase full bridge inverter. The simulation results of PI and FL controlled closed loop systems are compared. This paper has presented a simulink model for the closed loop controlled solar system.

Key words: Bidirectional inverter · Buck/Boost Converter · Maximum power point trackers (MPPTs) · Fuzzy Logic Controller (FLC) · Proportional Controller (PI) · Pulse Width Modulation (PWM) · DC-distribution applications · Sim Power System

INTRODUCTION

Due to energy Crisis and environmental issues such as pollution and global warming effect, photovoltaic (PV) systems are becoming a very attractive solution. Unfortunately the actual energy conversion efficiency of PV module is rather low. So to overcome this problem and to get the maximum possible efficiency, the design of all the elements of the PV system has to be optimised.

In order to increase this efficiency, MPPT controllers are used. Such Controllers are becoming as essential element in PV systems. A significant number of MPPT control schemes have been elaborated since the seventies, starting with simple techniques such as voltage and current feedback based MPPT to more improved power feedback based MPPT such as the Proportional Controller (PI) technique. Recently intelligent based MPPT control schemes have been introduced. The schematic diagram of the non-isolated buck-boost converter is shown in Fig. 1.

An intelligent control technique using fuzzy logic control is associated to an MPPT controller in order to improve energy conversion efficiency. Power-Management strategies for a grid connected PV-FC hybrid system is given by L.N. Khanh [1]. Optimized wind energy harvesting system using resistance emulator and active rectifier for wireless sensor nodes is given by Y.K. Tan [2]. A hybrid cascade converter topology with series-connected symmetrical and asymmetrical diode-clamped H-Bridge cells is given by A. Nami [3]. An efficient high-step-up interleaved DC-DC converter with a common active clamp is given by S. Dwari [4]. Transformer less grid connected power converter for PV system is given by J.M. Shen [5] and T. Kerekes [6] respectively. Adaptive fuzzy controlled wind energy system is given by M. A. Azzouz [7]. Distribution voltage control for DC microgrid using stored energy is presented by H. Kakigano [8]. Predictive controlled bi-directional inverter for microgrid applications is given by T.F. Wu [9]. Multilevel inverter for grid-connected PV system employing digital PI controller is given by J. Selvaraj [10].

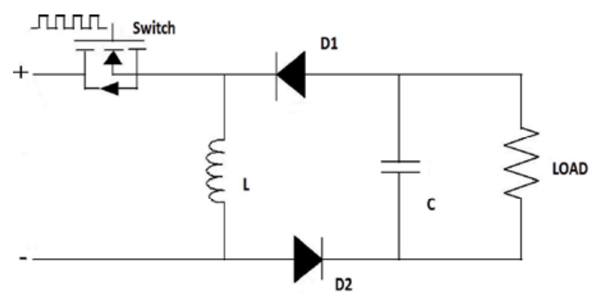

Fig. 1: Schematic diagram of the non-isolated buck-boost converter

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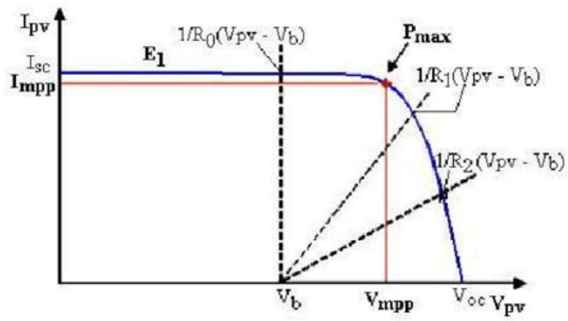

Fig. 2: Current-Voltage Characteristics of a PV module

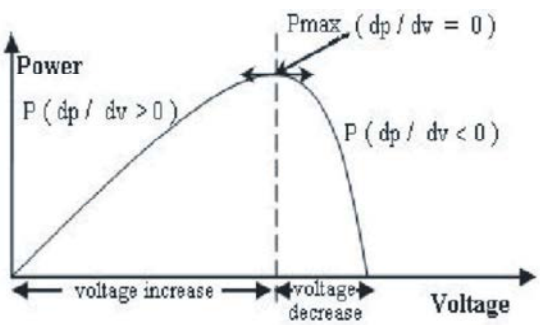

Fig. 3: Power-Voltage Characteristics of a PV module

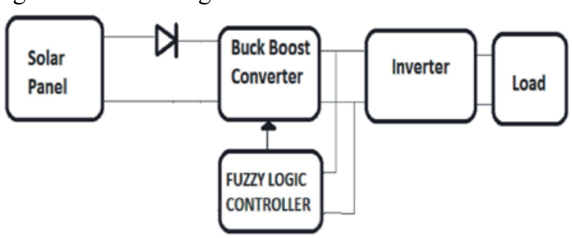

Fig. 4: Photovoltaic system Using FLC

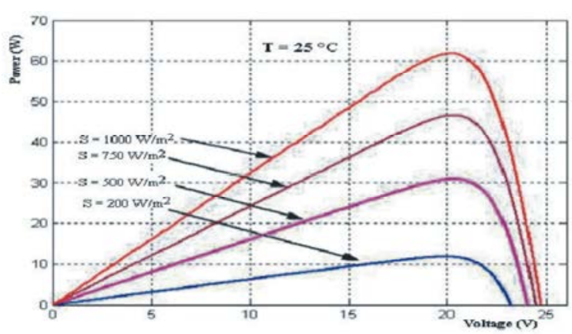

Fig. 5: Influence of the solar radiation for constant temperature.

Indirect DC-link voltage control of two-stage single-phase PV inverter is given by F. Gao [11]. Robust DC-link voltage control scheme for photovoltaic power generation system PCS is given by J. S. Park [12]. A stable mode-transition technique for a digitally controlled non inverting buck-boost dc-dc converter is given by C. H. Tsai [13]. High efficiency two-switch tri-state buck-boost

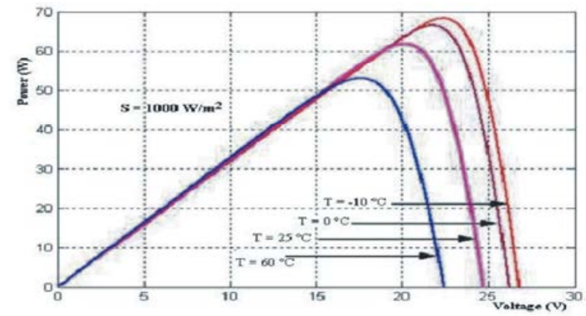

Fig. 6: Influence of the temperature of junction for constant Insulation

power factor correction converter with fast dynamic response and low inductor current ripple is given by M. He [14]. Single-inductor dual-output Buck boost power factor correction converter is given by X. Liu [15]. Fuzzy Identification of Systems and its Applications to Modeling and Control is given by T. Takagi [16]. Analysis, design and implementation of isolated bidirectional converter with winding-cross-coupled inductors for high step-up and high step-down conversion system is given by W. Li [17].

The above literature does not cover comparison of PI and FLC based closed loop controlled buck boost converter inverter based systems. This work aims to develop closed loop simulink model for buck boost converter inverter based solar system employing the FLC. The FLC is proposed for the control of buck boost converter based solar system.

Principle of Maximum Power Point Tracking Control: The photovoltaic module operation depends strongly on the load characteristics are shown in Fig. 2 and Fig. 3 to which it is connected. Indeed, for a load, with an internal resistance R_i, the optimal adaptation occurs only at one particular operating point, called Maximum Power Point Tracking (MPPT) and noted in our case P_{max}.

Thus, when a direct connection is carried out between the source and the load, the output of the PV module is seldom maximum and the operating point is not optimal. To overcome this problem, it is necessary to add an adaptation device, MPPT controller with a DC-DC converter, between the source and the load. The Photovoltaic system using FLC is shown in Fig. 4. [18].

Furthermore the characteristics of a PV system vary with temperature and insolation is shown in Fig. 5 and Fig. 6. So, the MPPT controller is also required to track the new modified maximum power point in its corresponding curve whenever temperature and isolation variation

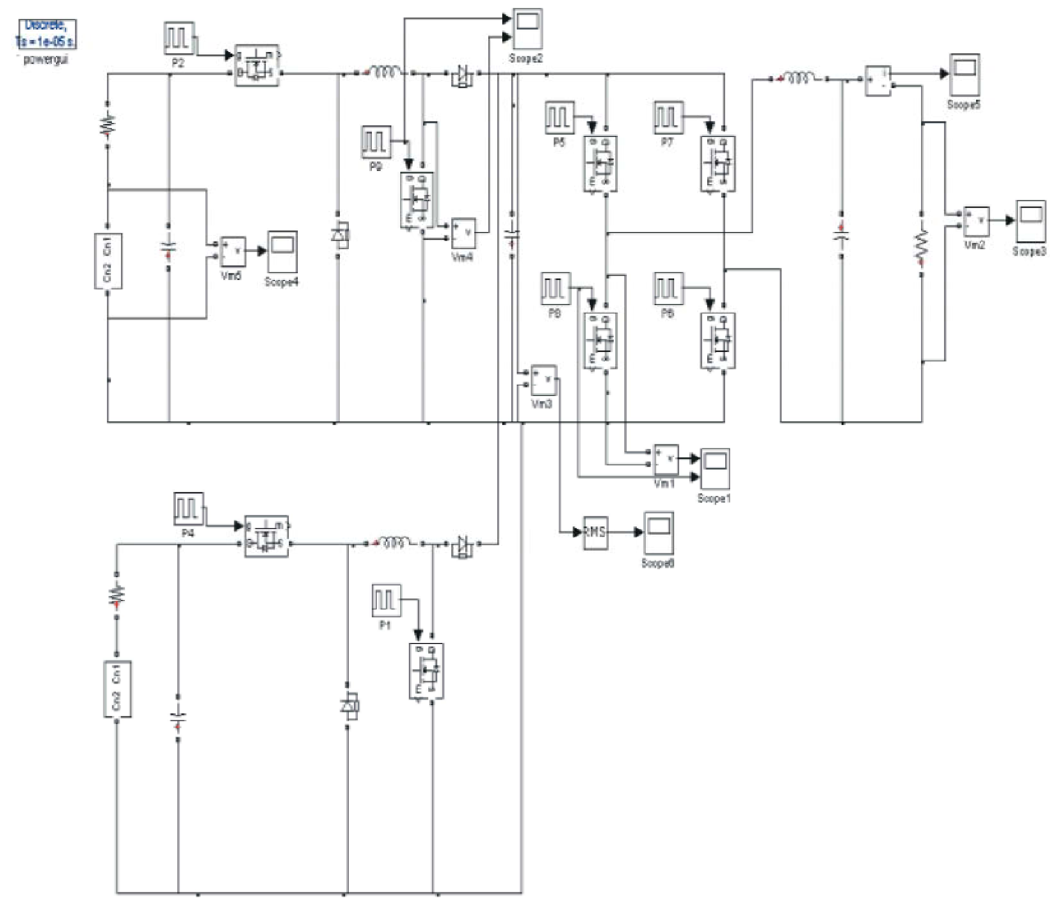

Fig. 7: Open loop Controlled system with step change in input

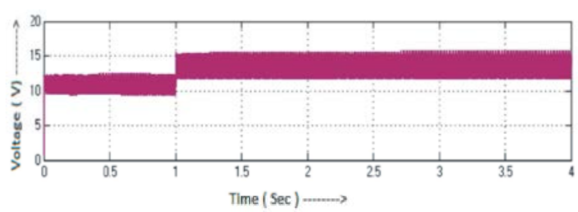

Fig. 7a: Input Voltage of the Solar System.

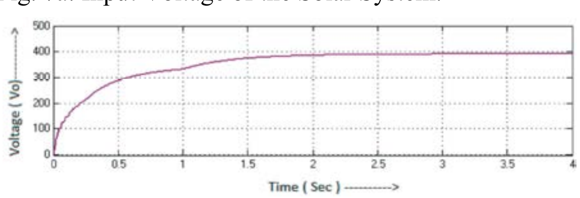

Fig. 7b: Output Voltage of the Buck - Boost Converter

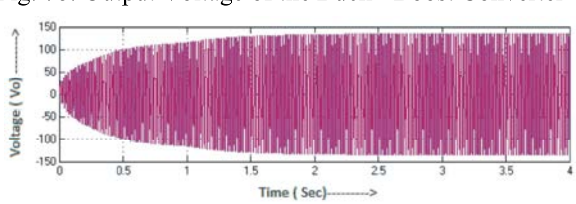

Fig. 7c. Output Voltage of the Inverter

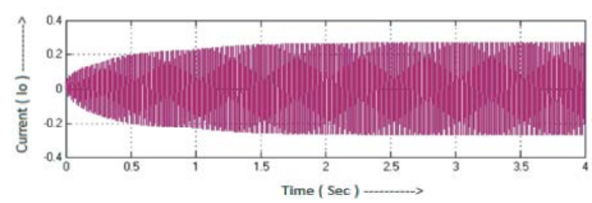

Fig. 7d: Output Current of the Inverter

occurs. The operational- mode transition control between buck and boost is also used. Combined buck and boost converter is proposed in this paper, in which the control or tracking maximum power points is based on a Fuzzy Logic Controller (FLC) method.

Simulation Results: Open loop system with step change in input is shown in Fig. 7. The step change in input due to increase in the solar energy is shown in Fig. 7a. The output voltage of boost converter is shown in Fig. 7b. The voltage increases from 320V to 390V. The AC output voltage and load current are shown in Fig. 7c and Fig. 7d respectively. It can be seen that the steady state error in the output voltage and current is higher.

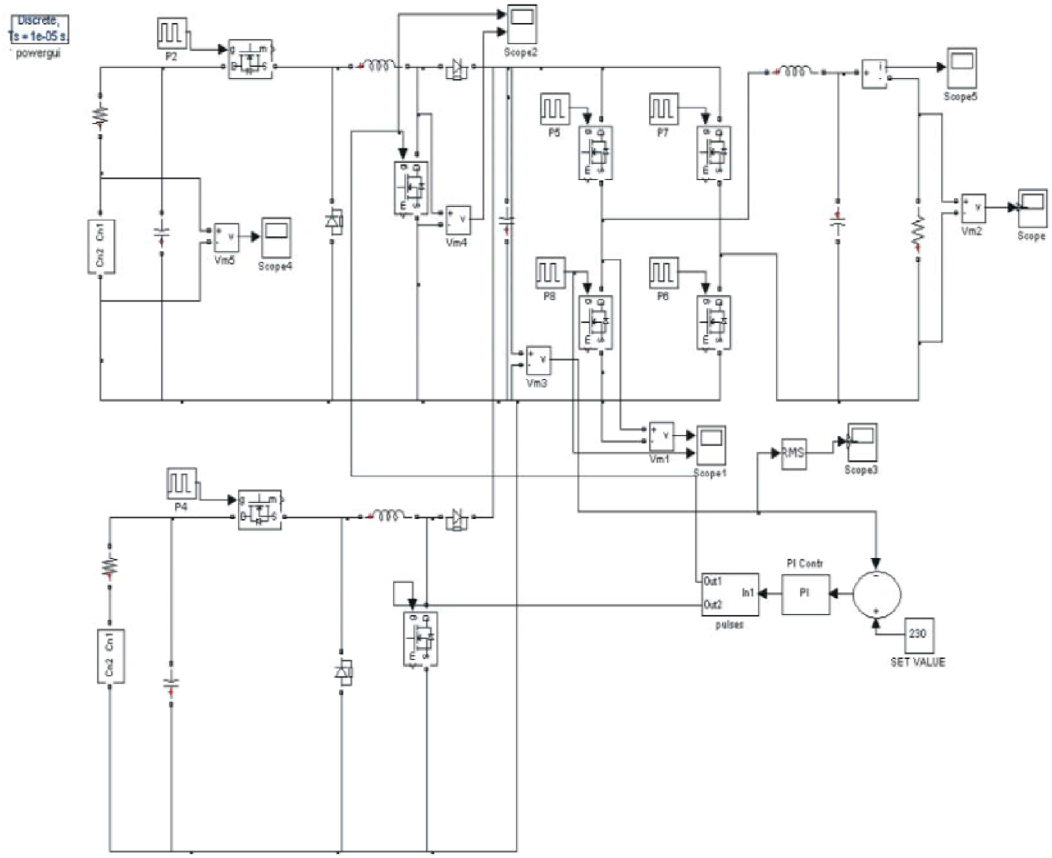

Fig. 8: Simulink Model of the Closed Loop System with PI

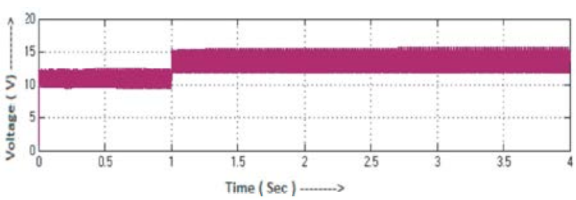

Fig. 8a: Input Voltage of the Solar System

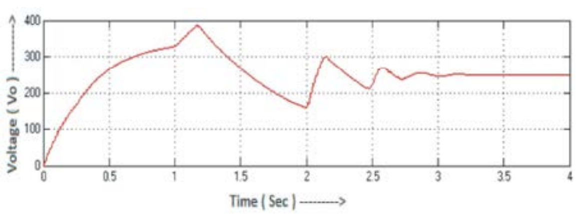

Fig. 8b: Output Voltage of the Buck -Boost Converter

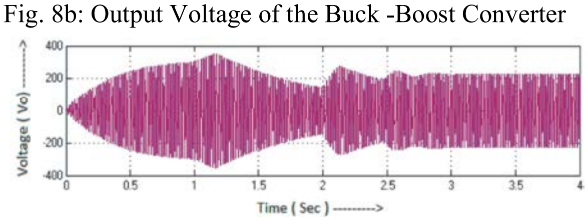

Fig. 8c: Output Voltage of the Inverter

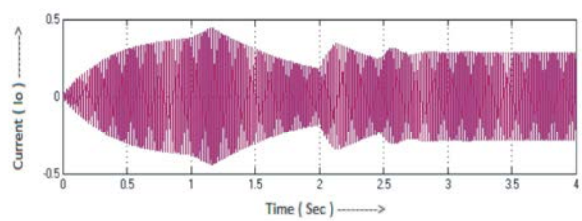

Fig. 8d: Output Current of the Inverter

The Simulink diagram of the closed loop system with PI is shown in Fig. 8. The DC output voltage of the boost converter is compared with the reference voltage. The error is processed using a PI controller. The output of the PI controller is used to update the pulse width applied to the buck boost converter. The step change in input voltage is shown in Fig. 8a. The input voltage increases from 10V to 14V. The output of the boost converter is shown in Fig. 8b. The output voltage decreases and settles at 240V. The output voltage and current waveforms are shown in Fig. 8c and Fig. 8d respectively.

Closed loop system with the FLC is shown in Fig 9. The PI controller is replaced by the FLC. The inputs to the FLC are the error and its derivative. The increase in input

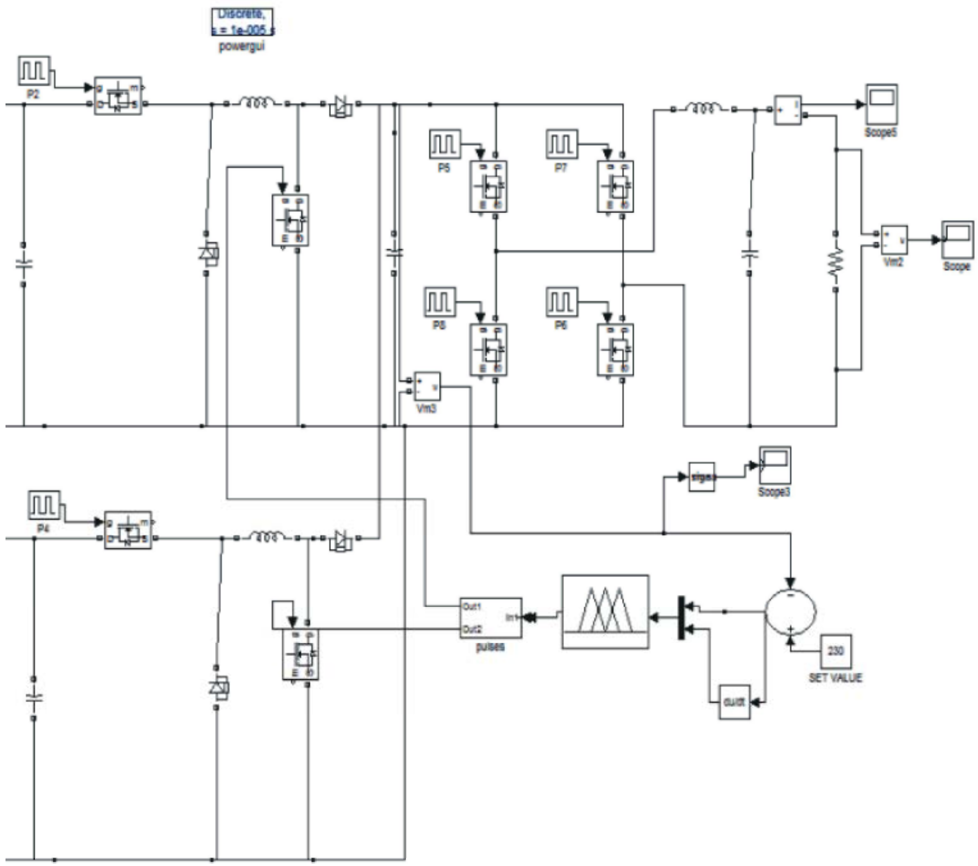

Fig. 9: Simulink Model of the closed loop System with FLC

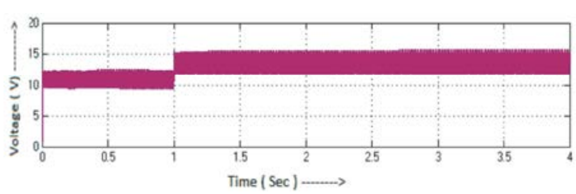

Fig. 9a: Input Voltage Solar System

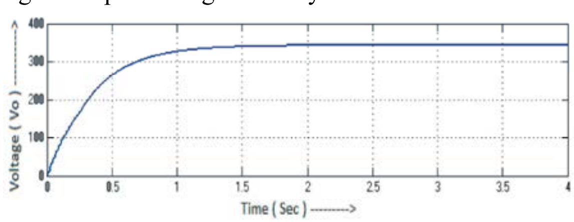

Fig. 9b: Output Voltage of the Buck - Boost Converter

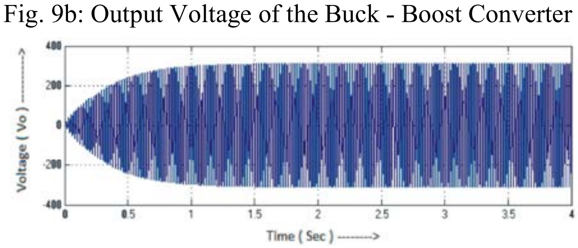

Fig. 9c: Output Voltage of the Inverter

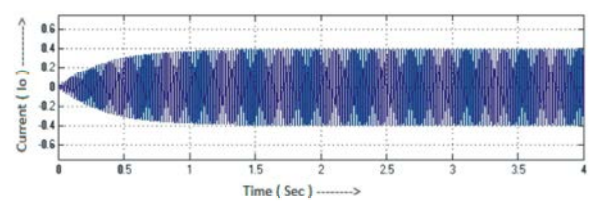

Fig. 9d: Output Current of the Inverter

Table I: Comparison between PI and FLC

Controllers	Rise time (s)	Peak time (s)	Settling time (s)	Steady state error (v)
PI controller	1.1	1.2	2.8	5
FLC	0.8	0.85	0.9	0.04

due to increase in insulation is shown in Fig 9a. The input voltage increases from 12V to 14V. The output of the buck boost converter is shown in Fig 9b. The output voltage and current of the inverter are shown in Fig 9c and Fig 9d respectively. The comparison between PI and FLC is given in Table I. The settling time and steady state error are very much reduced using FLC.

CONCLUSION

Closed loop controlled parallel cascaded buck boost converter inverter systems with PI and FLC are successfully modelled and simulated using sim power system. The results of open loop and closed loop systems were presented. The closed loop system was capable of reducing the steady state error to minimum value using FLC. The simulation results were in line with the predications. The closed system had advantages like improved response and reduced steady state error. The disadvantage of this system was that it had limited voltage tracking range.

The scope of this work is the simulation of closed loop controlled converter – inverter system with PI and FL controllers. The closed loop simulation using neural network controller will be done in future.

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