International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 4 (2015) pp. 10187-10198

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Investigations on Dual Half Bridge Dc - Ac Converter For Pv Generation

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Abstract

This work deals with the modelling and the simulation of the closed loop controlled dual half bridge DC to AC converter system (DHBDACS) for PV generation. Dual Half Bridge(DHB) converter is combined with low frequency inverter to produce single phase power with the line frequency of 50 Hz. Low voltage DC is stepped up using DHB and it is converted to AC using a half bridge inverter. Closed loop PI & PID controlled systems are modelled and simulated using Simulink and the corresponding results are compared.

Introduction

DC-SOURCE distributed generators (DGs) such as photo- voltaic solar cells or fuel cells require a DC-DC converter and inverter for grid connection or to supply household electricity. For small power rating DGs, isolation types are preferred for safety and simplicity when grounding. Since 50-Hz trans- formers are bulky, heavy, and costly, it is better to isolate them by using a high-frequency transformer.

The dual-active-bridge (DAB) converter [1], [2] is suitable for isolating type high power transfer systems. It is effective for achieving high power density, galvanic isolation, zero-voltage switching (ZVS), bidirectional power transfer capability, and modular structures [1]–[4], [15]. Dual-half-bridge (DHB) topology requires only half as many switching devices as the dual- full-bridge topology [6]–[9], [13], [19]. However, the major drawback of the half-bridge is that the split DC-link capacitors have to handle the full load of the current. Therefore, the DHB converters are more suited to low power applications [8].

Since the DAB circuit carries two AC sources on both sides of the transformer, the power flow is controlled via the phase angle difference between the primary and the secondary voltage vectors. Therefore, the most popular DAB control method is to change the phase-shift while keeping a 50:50 ON–OFF duty ratio between the switches [1], [2], [4], [8], [16], [17], [24]. Non 50:50 duty control methods were proposed for the DAB converter to reduce the current stress and to extend the ZVS range in [9] and [13] and to operate in buck–boost mode [19]. In other research, reduced pulsewidth controls were used to extend the ZVS or power range and to reduce the peak current at low loads [10], [14], [15], [23]. Bai [18] and Mi proposed a dual- phase-shift control strategy that utilized a phase shift between the gate signals of the diagonal switches of each H-bridge.

In this paper, a DHB converter circuit combined with a single- phase inverter is proposed for a possible application as a single- phase DG topology. The above literature does not deal with comparison of PI and PID controlled DAB AC-AC converter system. This work deals with comparison of PI & PID controlled closed loop systems.

Proposed Topology

A. Converter and Inverter Topology

Fig. 1 shows the proposed DHB circuit that is combined with a single-phase 50-Hz inverter. It is basically a converter–inverter system targeted for household electricity in the range of 1–3 kW. The distributed resource shown in Fig. 1 can be a photovoltaic solar cell or a fuel cell. The DHB structure ensures bidirectional power flow between the power source and the local load, while also providing galvanic isolation. Many previous researchers assumed the use of 50-Hz transformers for isolation [20]–[22], but 50-Hz transformers are bulky and costly. In this topology, the isolation is achieved via a 100-kHz transformer. As a result, the transformer size is reduced significantly.

Note that the DHB converter is directly connected to a single- phase half-bridge inverter, i.e., the DHB secondary capacitors are shared with the half-bridge inverter. This topology reduces the number of required parts. Furthermore, note that the DC-link center tap is shared in common by the converter secondary and the inverter. Therefore, this topology makes it possible to cure the unbalanced capacitor-voltage problem by manipulating the converter switching time asymmetrically.

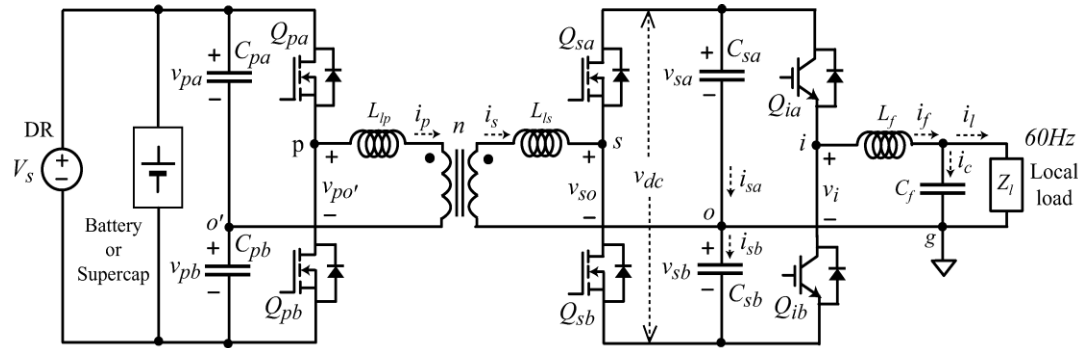

Figure 1: Proposed DHB combined with a single-phase half-bridge inverter

B. Control Strategy

As the 50-Hz load current flows through the DC-link capacitors, the capacitor voltage schange: when i_f >0,theupper capacitor C_{sa} discharges and the lower capacitor C_{sb} is charged, while the center tap voltage increases with respect to the negative rail of the DC link. The phenomenon is reversed when $i_f < 0$. Therefore, the center tap voltage fluctuates around a level of 50 Hz as long as the inverter operates. This voltage fluctuation intensifies as the load current increases. The capacitors appear as a reactive source impedance to the load [5], [11], [12] so that the capacitor current distorts the output voltage form. By increasing the capacitance, the problem can be mitigated, but this increases the cost and system size.

To prevent the aforementioned shortcoming of the half-bridge inverter, we propose a method of engaging the converter switchings: the converter switches are controlled so that the capacitor- voltage unbalance is nullified. The proposed feed-forward technique is not based on an *a priori* calculation, but instead, it is based on the measured values of the capacitor voltages.

Simulation Results

Open loop system with a step change in input is shown in Fig 2a. The change in input voltage is shown in Fig 2b.The primary voltage of the transformer is shown in Fig 2c. The secondary voltage is shown in Fig 2d.The output of the rectifier is shown in Fig 2e.The output of the rectifier increases from 200V to 260V.The output voltage, current and power of the inverter are shown in Figs 2f, 2g&2h respectively. The peak value of output voltage increases from 220V to 300V. It can be seen that there is a large steady state error in the output voltage of rectifier and inverter.

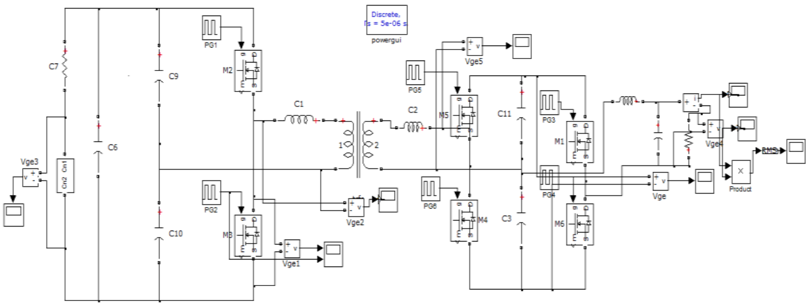

Figure 2a: Open Loop Circuit

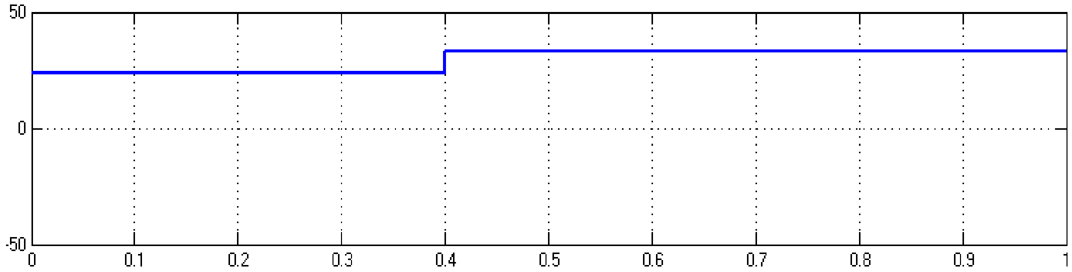

Figure 2b: Input voltage

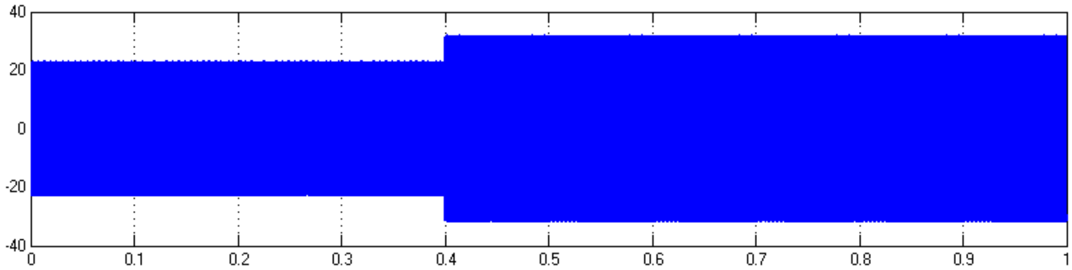

Figure 2c: Primary voltage of Transformer

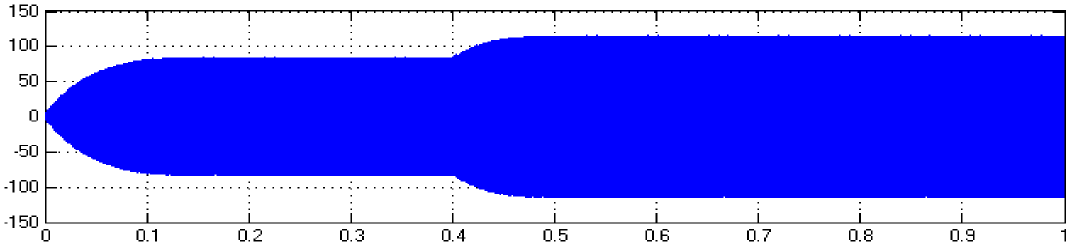

Figure 2d: Secondary voltage of Transformer

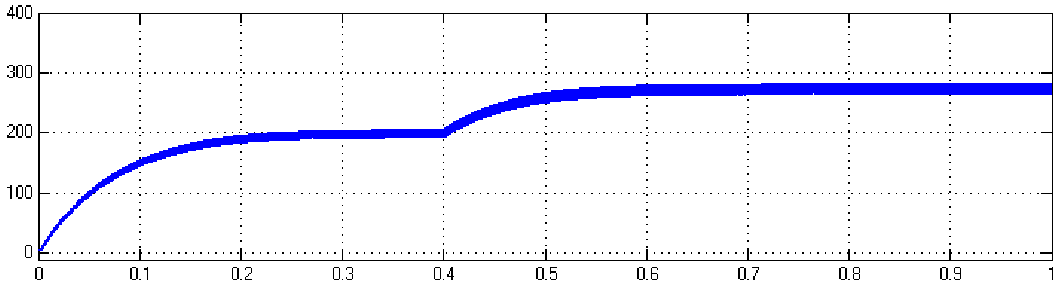

Figure 2e: Output voltage of the Rectifier

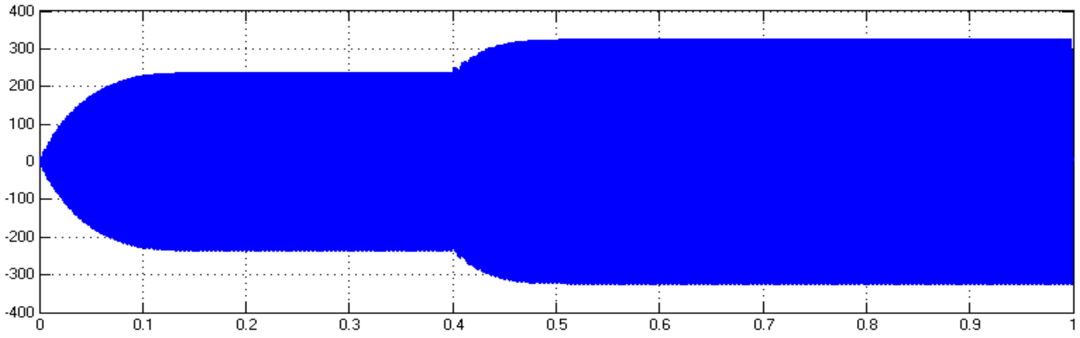

Figure 2f: Output voltage of the Inverter

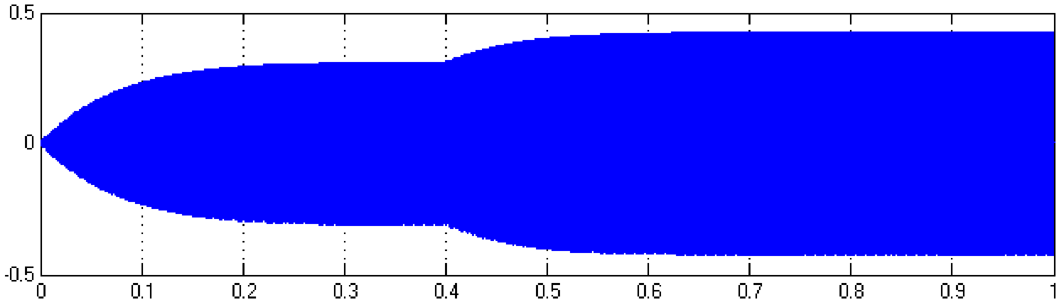

Figure 2g: Output Current

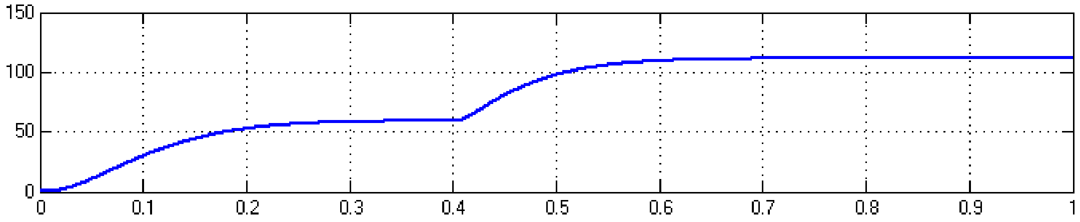

Figure 2h: Output Power

Closed loop PI controlled system is shown in Fig 3a. The output of the rectifier is compared with the reference voltage. It is amplified and applied to a comparator through a PI controller. The pulse width applied to the rectifier is controlled to maintain constant voltage at the output. Step change in input voltage and primary voltage are shown in Figs 3b & 3c respectively. The output voltage and current settle at the required value.

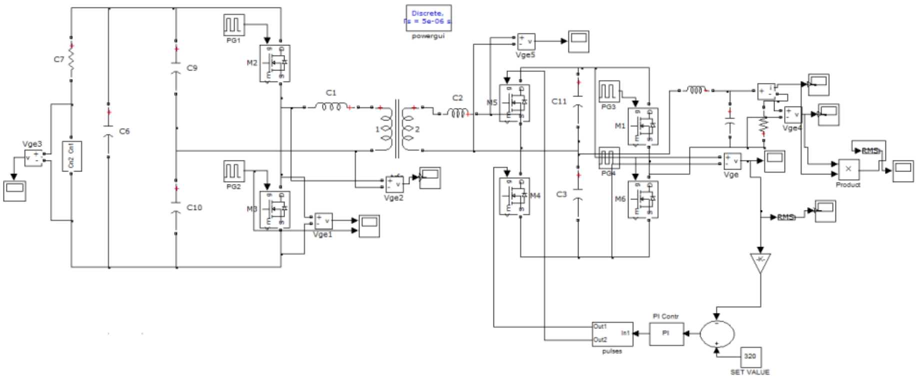

Figure 3a: Closed Loop circuit with PI control

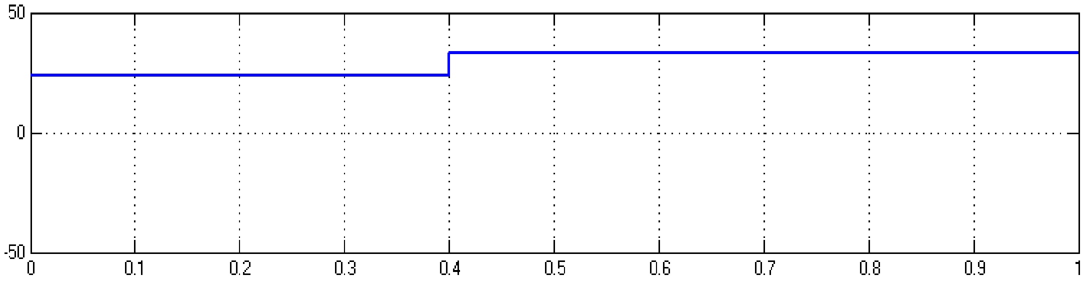

Figure 3b: Input Voltage

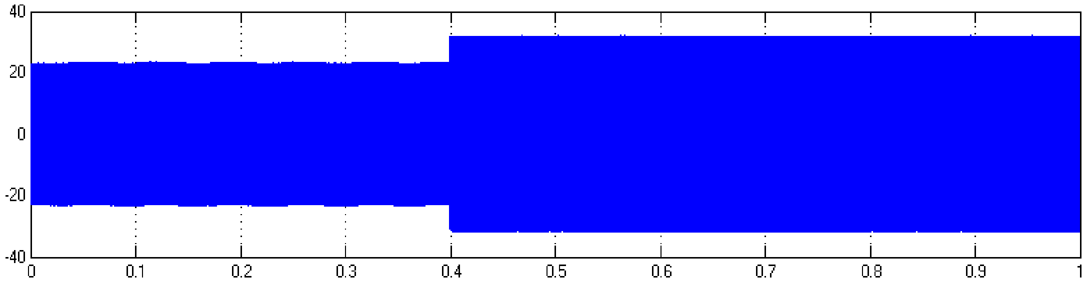

Figure 3c: Primary voltage of the Transformer

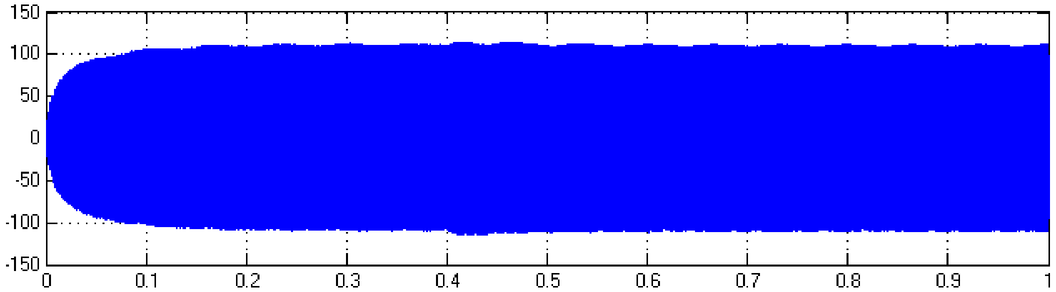

Figure 3d: Secondary voltage of the Transformer

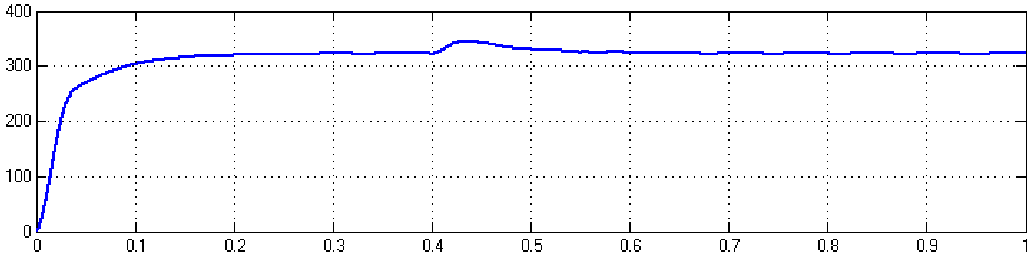

Figure 3e: Output voltage of the Rectifier

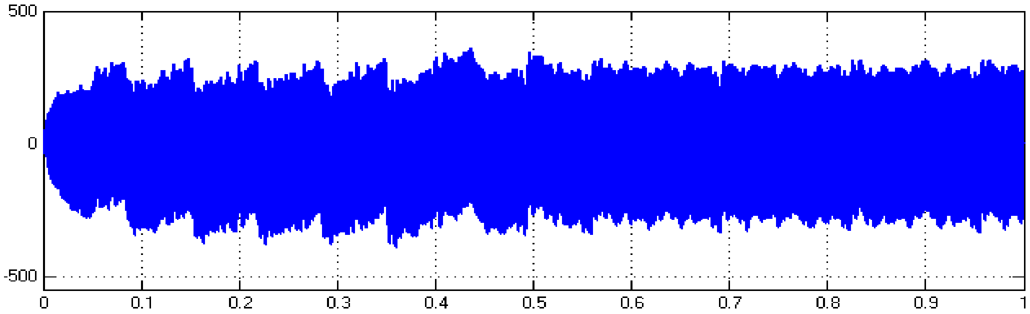

Figure 3f: Output voltage of the Inverter

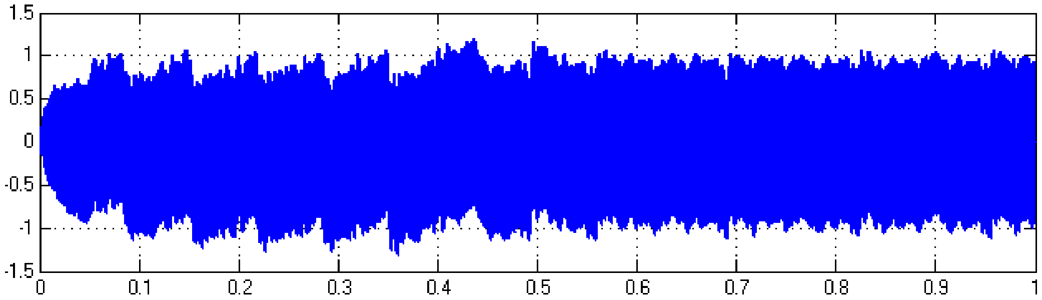

Figure 3g: Output current of the Inverter

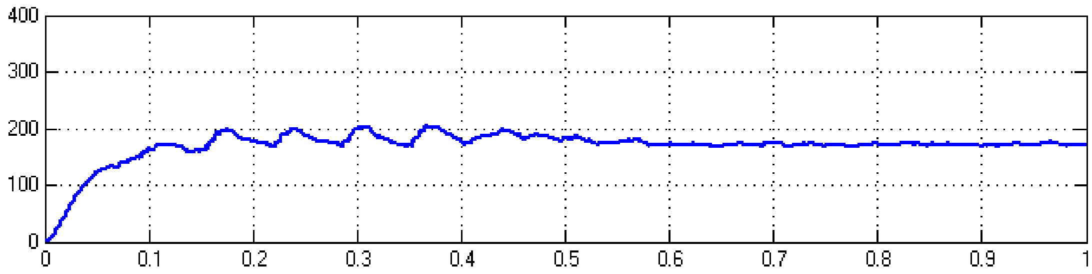

Figure 3h: Output power

Closed loop system with PID controller is shown in Fig 4a.The step change in input voltage is shown in Fig 4b. The input voltage increases from 20V to 25V.The secondary voltage of the transformer is shown in Fig 4d.Output voltage of rectifier is shown in Fig 4e.The output voltage of the inverter is shown in Fig 4f.Output current and Output power are shown in Figs 4g & 4h respectively.

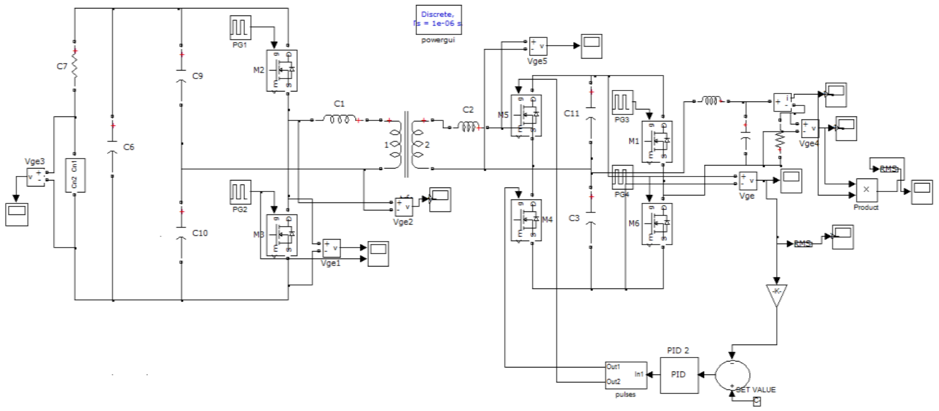

Figure 4a: Closed loop system with PID controller

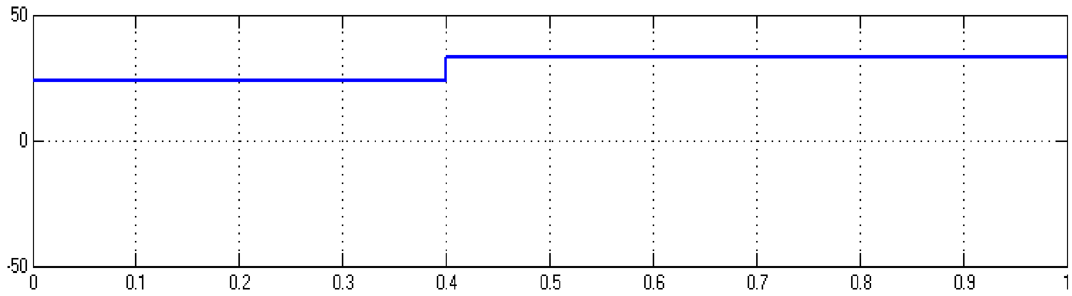

Figure 4b: Input Voltage

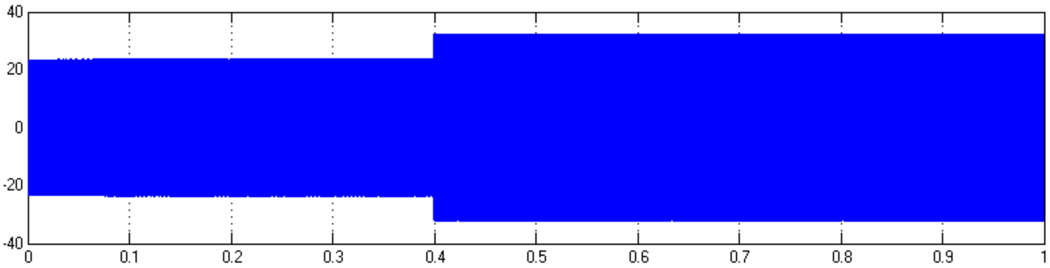

Figure 4c: Primary voltage of the Transformer

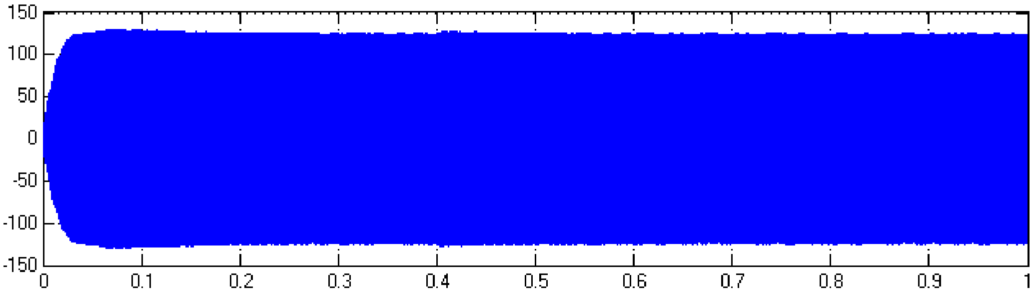

Figure 4d: Secondary voltage of the Transformer

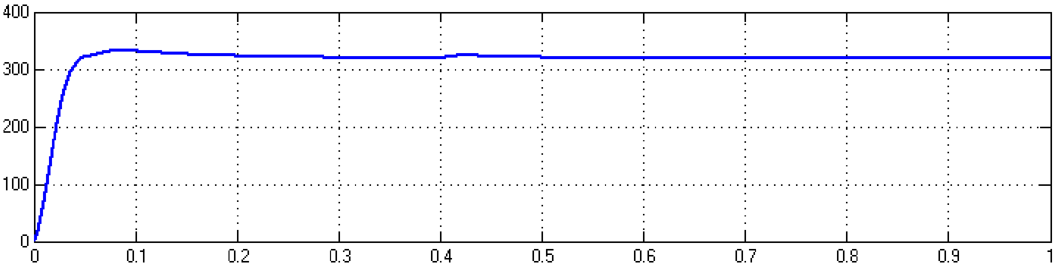

Figure 4e: Output Voltage of the Rectifier

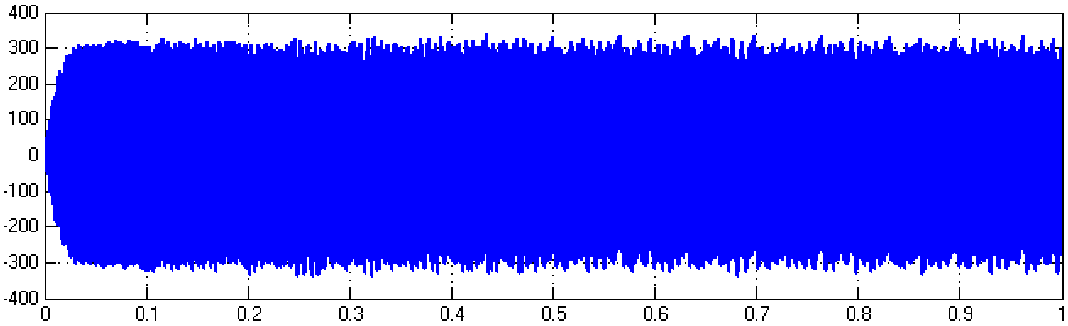

Figure 4f: Output Voltage

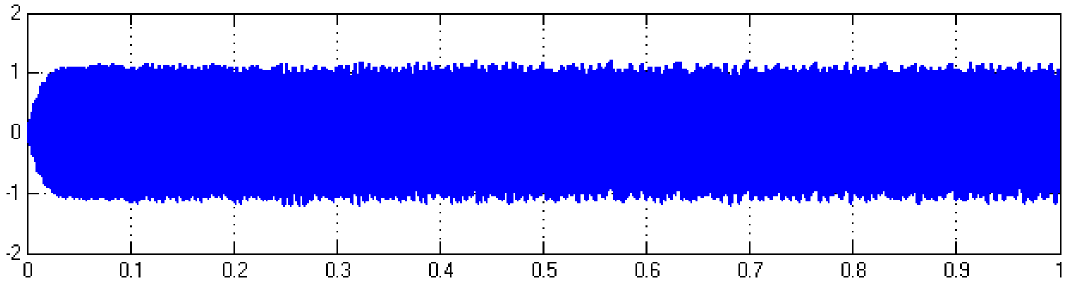

Figure 4g: Output Current

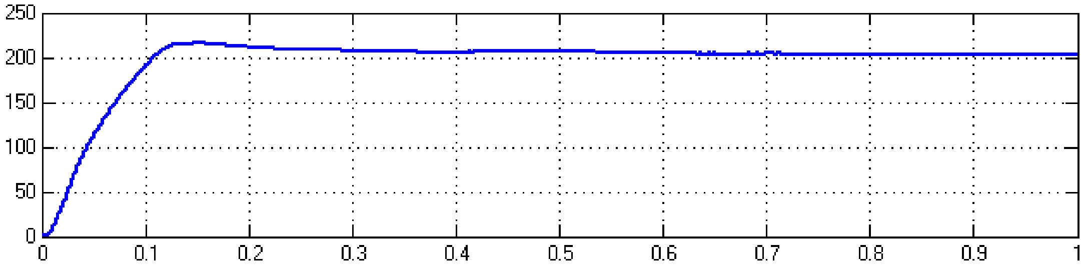

Figure 4: Output power

The comparison of PI & PID controlled systems is given in Table I. It can be seen that the rise time and the settling time are reduced using PID controller. The Peak voltage and the steady state error are also reduced by using PID controller.

Table 1: Comparison of PI &PID Controlled systems

converter	**Tr** sec	**Ts** sec	**Vp** volts	**Ess** volts
PI controller	**0.07**	**0.51**	**4.5**	**0.8**
PID controller	**0.04**	**0.43**	**3.5**	**0.5**

Conclusion

Dual half bridge DC-AC converter system for PV generation is designed, modelled and simulated. The simulation results with PI and PID controller are presented. The comparison indicates that PID is a viable alternative to the PI controller. This system has advantages like reduced transformer size, reduced filter size and high power transfer ability. The drawback of this system is that it requires six MOSFETs and six drivers.

This work deals with comparison of PI & PID Dual Half Bridge DC -AC converter system. The comparison between PID & Fuzzy Controlled DHBDACS will be done in future.

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