PERFORMANCE ANALYSIS OF LLC RESONANT CONVERTER INCORPORATING PI FUZZY AND NEURAL CONTROLLERS

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ABSTRACT

The existing literature predominantly concentrates on the design of the modified LLC type of resonant converter and the implementation of state space modeling. In this paper, several performance inquiries of PI, Fuzzy and Neural control have been engaged for LLC Resonant Converter. In this recommended converter an input voltage (40V) has been converted in to output voltage of 220V. The results of various controllers for LLC Resonant Converter have been effectively compared and calculated different Time Domain Specifications (TDS) such as Delay time, Rise time, Peak overshoot, Peak time and Settling time. It can be concluded that the performance of neural controller sensitiveness is practically less compared with PI and Fuzzy controller.

Key words: LLC Resonant Converter, PI controller, Fuzzy controller, Neural controller

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NOMENCLATURE

V_{dc} - Input voltage
 V_o - Output voltage
 C_f - The Filter capacitor
 C_p - The Parallel capacitor
 F_r - The Resonant frequency

ABBREVIATION

PI - Proportional Integral
RC -Resonant converter
ZVS - Zero Voltage Switching
ZCS - Zero Current Switching
SRPC - Series Parallel Resonant Converter
PFC- Power Factor Correction
FLC - Fuzzy Logic Controller

1. INTRODUCTION

In recent years efforts are being made towards the improvement of DC-DC converter efficiency by reducing switching loss[1-3]. The aim of the suggested LLC converter is to deliver significant efficacy under instabilities in line and load sides [4]. The Resonant converter applications are fluorescent lamp, filament heating, SMPS, etc. The five sections of proposed work deal with; Section I- The Design procedure of Resonant Converter. Section II- Design of PI, Fuzzy and Neural Controllers. Section III- displays the simulation results and section IV- shows Performance Analysis of different controllers. Section V- illustrates the conclusion of proposed work.

2. RESONANT CONVERTER (RC)

Resonant Converters (RC) have age of thirty years old and where much effort has been spent in research at university and industry levels [5-7]. It is a switching converter that includes a tank circuit which actively participates in determining the output power flow[8-10].The losses due to switching remade less by incorporating Zero voltage switching (ZVS) and basic snubber circuits. The SPRC topology combines the advantages of both parallel as well as series resonant converter [11-13]. At last, the particular regions of the tank raise some harmonics; it is used to send real power which is finally served like a tool to reduce the peak electrical stresses in load side [14]. Figure 1 shows the Circuit diagram of modified LLC Resonant Converter.

Fig 1. Circuit diagram of modified LLC Resonant - Boost Converter

3. DESIGN OF CONTROLLERS

3.1. PI Controller

The Proportional integral (PI) controller is amongst the conventional controllers. It is mostly used to control the speed. The major feature of the PI controller is the capability to keep constant zero steady-state error. The combination of PI is essential to raise the speed of the system response and to reduce the steady-state error. The circuit errors are reduced by trial and error method. The controlled signals are given to RC and Linear transformer [15]. The PI controllers are a special case; they are usually used for controlling various systems. It has some errors such as proportional and integral errors. Then the output is increased by terms of proportional constant K_p . The integral error also affects the output values [16-17]. The output is increased in terms of integral constant K_i . The gain K_p and K_i are correcting ports to modify the preferred output response. The PI controller has the advantages of increasing system stability. Figure 2 Shows the Block diagram of LLC Resonant Converter Fed Resistive Load using PI Controller.

Figure 2 Block diagram of LLC Resonant Converter Fed Resistive Load using PI Controller

3.2. Fuzzy Logic Controller (FLC)

FLC works under the principle of FUZZY logics. Fuzzy logic provides conventional and user friendly frontend to develop the control programs. Fuzzy controllers have the tendency to oscillate around the final operating point [18]. It is the processes of converting the crisp data into a linguistic member function. For the given input and output the mapping is formulated. There are seven linguistic member functions. They are NB, N, NS, ZE, PS, P, PB. It is done by using Takagi-Suge no method [19-20]. Fuzzy logic is a very powerful tool and successful implementation in every field. Fuzzy controller has several advantages over PI controller. The fuzzy controller is more beneficial because of its simple design, robust, cheap, and multiple inputs and multiple outputs. Figure 3 Shows the Block diagram of LLC Resonant Converter Fed Resistive Load using Fuzzy Controller.

Figure 3 Block diagram of LLC Resonant Converter Fed Resistive Load using Fuzzy Controller

3.3. Neural Controller

The Neural Controller is subject to the Data Processing Unit. It has more interconnected processing elements. It acts as the brain of the constructed architecture. The important function of the controller is to give the preferred output. The Neural network has its own erudite and intrigue capabilities which able to adjusting the changes in data. The input and output data are important to obtain the desired output values. The data set is adequate and enough to confirm the constant operation. So there is no requirement of erudite after operation. In the Neural Controller the feedback system and pre-filters are multilayered. The Neural controller has different models such as Single input and multiple input models. The rear transmission procedure is used to run the constructed network. This procedure is commonly controlled transmission system for multilayered network. Figure 4 Shows the Block diagram of LLC Resonant Converter Fed Resistive Load using Neural Controller.

Figure 4 Block diagram of LLC Resonant Converter Fed Resistive Load using Neural Controller

4. SIMULATION RESULTS

The simulation results show the response of the various controllers of LLC-RC for the response of 40V in load 100Ω . PI, Fuzzy and Neural controller has the response of output voltage and current in line disturbance (40V-38V-40V) at 0.55 sec through load 100Ω and in load disturbance (100Ω -90 Ω -100 Ω) at 0.55sec in 40V. Equally, the performances of the PI, Fuzzy and Neural controllers are compared with one another.

4.1. PI Controller

Under Nil Disturbance

Figure 5 Simulated voltage response of LLC-RC under nominal load 100Ω and input voltage 40V.

Figure 6 Simulated current response of LLC-RC under nominal load 100Ω and input voltage 40V.

Under Line Disturbance

Figure 7 Simulated voltage response of LLC-RC under line disturbance (40V-38V-40V) at $t=0.55\text{sec}$.

Figure 8 Simulated current response of LLC-RC under line disturbance (40V-38V-40V) at $t=0.55\text{sec}$.

Under Load Disturbance

Figure 9 Simulated voltage response of LLC-RC under load disturbance (100Ω - 90Ω - 100Ω) at $t=0.55\text{sec}$.

Figure 10 Simulated current response of LLC-RC under load disturbance (100Ω - 90Ω - 100Ω) at $t=0.55\text{sec}$.

4.2. Fuzzy Controller Under Nil Disturbance

Figure 11 Simulated voltage response of LLC-RC under nominal load 100Ω and input voltage 40V.

Figure 12 Simulated current response of LLC-RC under nominal load 100Ω and input voltage 40V.

Under Line Disturbance

Figure 13 Simulated voltage response of LLC-RC under line disturbance (40V-38V-40V) at $t=0.55\text{sec}$.

Figure 14 Simulated current response of LLC-RC under line disturbance (40V-38V-40V) at $t=0.55\text{sec}$.

Under Load Disturbance

Figure 15 Simulated voltage response of LLC-RC under load disturbance (100Ω - 90Ω - 100Ω) at $t=0.55\text{sec}$.

Figure 16 Simulated current response of LLC-RC under load disturbance (100Ω - 90Ω - 100Ω) at $t=0.55\text{sec}$.

4.3. Neural Controller

Under Nil Disturbance

Figure 17 Simulated voltage response of LLC-RC under nominal load 100Ω and input voltage 40V.

Figure 18 Simulated current response of LLC-RC under nominal load 100Ω and input voltage 40V.

Under Line Disturbance

Figure 19 Simulated voltage response of LLC-RC under line disturbance (40V-38V-40V) at $t=0.55\text{sec}$.

Figure 20 Simulated current response of LLC-RC under line disturbance (40V-38V-40V) at $t=0.55\text{sec}$.

Under Load Disturbance

Figure 21 Simulated voltage response of LLC-RC under load disturbance (100Ω - 90Ω - 100Ω) at $t=0.55\text{sec}$.

Figure 22 Simulated current response of LLC-RC under load disturbance (100Ω - 90Ω - 100Ω) at $t=0.55\text{sec}$.

5. PERFORMANCE ANALYSIS

Table.1 Represents the performance investigation of the LLC-RC under line and load disturbance with PI, Fuzzy and Neural controllers. Fig.23 shows a graphical comparison of PI, Fuzzy and Neural controller's performances of LLC-RC.

Table 1 Comparison of various parameters of different controllers under nominal load 100Ω .

Controllers	Startup transient					Supply disturbance Supply decreases by 2 V		Load disturbance Load decreases by 10 Ω	
	Delay time (sec)	Rise time (sec)	Peak over shoot (%)	Peak time (sec)	Settling time (sec)	Peak over shoot (%)	Settling time (sec)	Peak over shoot (%)	Settling time (sec)
PI	0.02	0.03	0.025	0.05	0.055	0.026	0.06	0.010	0.06
FUZZY	0.01	0.025	-	-	0.035	-	0.059	-	0.059
NEURAL	0.005	0.01	-	-	0.005	-	0.058	-	0.058

From the above table it was evident that Neural controller controls different Time Domain Specifications (TDS) effectively. It can be concluded that under the circumstances of supply and load disturbances, Neural controller settled down the responses faster than PI and Fuzzy controllers which is experimented by using MATLAB/SIMULINK.

Figure 23 Comparison graph of different parameters of various controllers under nominal load 100 Ω .

6. CONCLUSION

The performance of the closed loop LLC-RC is obtained by different controllers like PI, Fuzzy and Neural. The proposed model was exposed to line disturbance (40V-38V-40V) at $t=0.55\text{sec}$ under nominal load 100 Ω . The output voltage and current waveforms for all the controllers are observed. Also the load disturbances (100 Ω -90 Ω -100 Ω) were applied at $t=0.55\text{sec}$ under nominal input voltage for all the controllers and the output response were observed. The Time Domain Specifications (TDS) were calculated from the obtained results. Thus the results were compared with one another; the response of the LLC resonant converter using a neural controller gives the healthier performance than the Fuzzy and PI controller. The proposed converter maintains constant output parameters such as voltage and current in spite of various line and load disturbance.

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