HYBRID FUZZY-PID CONTROLLER IN BUCK-BOOST CONVERTER

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ABSTRACT
Different types of controlling methods are used in switched mode dc-dc converters and the controller which is simple and of low cost is always in demand. The different controllers used are PI controller, PID controller and Fuzzy logic controller. PI and PID controllers do not give good performance in non linear conditions. Fuzzy logic controller is a non linear controller which do not need exact information of mathematical model. Hybridization of the two controllers can be done to exploit the advantageous sides of both controllers to obtain better performance as compared to above two controllers.

Keywords - Buck-Boost Converter, Fuzzy logic controller (FLC), Hybrid Fuzzy-PID Controller, Matlab/Simulink.

1. INTRODUCTION
DC-DC converters are basically used to convert unregulated DC input voltage into regulated DC output voltage and to serve this purpose switch mode DC-DC converters are used[1]. Some converters can be used to generate output voltage which is less than input voltage, some are used to generate output voltage greater than input voltage and few to do the either functions. A buck boost converter is a converter that can generate output voltage either greater than or smaller than output voltage. Important difference is isolation between converters.

There are two different topologies in buck boost converter. One is inverting topology and second is non inverting topology. In Inverting topology output is opposite to that of input and the output is adjusted on the basis of duty cycle. There is one drawback in this converter is that switch does not have a terminal ground, this creates complications in circuit. However it does not have any consequence if power supply is isolated from the load. And therefore supply and diode polarity can be reversed by isolation of supply with load. The second one is the non inverting topology in which output will have the same polarity as input and it can generate output either smaller than or greater than the input.

![Figure 1: Buck-Boost Converter](image)

The converter consists of a dc input voltage source V_S, controlled switch S, inductor L_S, Diode D, a filter capacitor C and a load resistance R_L. When switch S becomes on, the inductor current increases and diode becomes reversed biased. When the switch is turned off, the diode provides a path for the inductor current.

![Figure 2: Basic idea of converter with controller](image)

2. FUZZY LOGIC CONTROLLER
A fuzzy logic controller is built up by a group of rules which are based on human knowledge about the system behaviour and design of fuzzy logic controller can provide desirable both small signal and large signal dynamic performance at same time, which is not possible with linear control technique i.e. PID control technique [2-4].
The main purpose of designer is to achieve output voltage which is equal to reference voltage. The most commonly used technique which is used to perform fuzzy inference method is Mamdani method. A Mamdani type Fuzzy Controller is designed for simulation of Buck-Boost Converter[5]. The inputs applied in FLC are:

- The voltage error (e) (reference voltage subtracted from actual voltage.)
- The change of the voltage error (ce) (previous error subtracted from current error) over one sample period.

Different shapes of membership functions are used to design FLC. And its value is normalized in [-1,1]. It can be represented in graphical forms. Shape of membership function has to be considered as an important criterion while design of fuzzy logic controller[6].

Figure 3: FLC controller in Buck-Boost converter

The membership function plot for error, change in error and output are shown below.

Figure 4: Fuzzy Inference System (FIS) Editor

Figure 5: Plot of Membership function for error

Figure 6: Plot of Membership function for change in error
The three basic steps to design FLC block are fuzzification, inference and defuzzification. Membership function plots are obtained and a set of IF-THEN Rules are formed for the controller. Then finally simulation and testing is done on the simulink model.

3. Hybrid Fuzzy-PID Controller

Classical PID controllers are the efficient techniques to fulfill the performance requirements despite the system uncertainties [7]. PID controllers are designed by adjusting $K_P$, $K_I$ and $K_D$ and this process is called tuning of controller. Fuzzy logic controller is digital and non linear controlling method which ensures large signal stability. However PID controllers results in minimum steady state error. Therefore the hybridization of the controllers i.e. PID controller and fuzzy logic controller came into an idea to utilize the beneficial sides of both the controllers.

Hybridization means combination of two different categories. It is a process to combine the performance of two different controllers to achieve better performance as compared to individual controllers. Fuzzy logic controller provides fast rise time and less percentage of overshoot [8]. PID controller provides low steady state error i.e. better accuracy. Therefore a hybrid model is designed using the two controllers which improves the performance of DC-DC Buck-Boost converter. The diagram shown below describes hybrid controller with the converter. The converter functions in buck mode for 0 to 0.1 seconds and in boost mode for 0.1 to 0.2 seconds.

4. Simulation Results

All schematic simulations are performed on Matlab/Simulink tool with input voltage 12 volt and reference voltage 10 volt and 30 volt. Simulation results of Fuzzy logic controller and Hybrid Fuzzy-PID controller in Buck-Boost converter circuit are shown. The model is tested in Buck mode for 0 to 0.1 seconds and in Boost mode for 0.1 to 0.2 seconds. FLC provides 9.62V in buck mode and 29.65 V in Boost mode whereas Hybrid Fuzzy-PID controller provides 9.84V in Buck mode and 29.87V. FLC controller provides deviation of 0.038% in buck mode and 0.1167% in boost mode whereas hybrid fuzzy-PID controller provides deviation of 0.016% in buck mode and 0.0043% in boost mode.
Figure 10: Output voltage and current waveform of Buck-Boost converter with (a) fuzzy logic controller and (b) Hybrid fuzzy-PID Controller

5. Conclusion
This paper has investigated the Hybrid Fuzzy-PID Controller for Buck-Boost converter. The output voltage waveform has been obtained for the two controllers. And it has been concluded that Hybrid Fuzzy-PID Controller provides better output voltage waveform as compared to Fuzzy logic controller.

References