# Reduction of Ripple in a single phase buck converter by Fuzzy logic control

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## ABSTRACT

**This paper presents the reduction of ripple by the use of fuzzy logic controller in a single phase buck converter. In Electrical science ripple means the unwanted residual periodic variation of the direct current output of a power supply which has been derived from an alternating current source. The ripple is due to incomplete suppression of the alternating current waveform within the power supply. As the ripple causes reduction in resolution of the measuring instruments, it should be reduced up to possible extent. When comparing with the other control techniques available for a DC-DC buck converter like Sliding mode control, Current mode control and Voltage mode control, Fuzzy logic control is the better one as it is mainly based on heuristic knowledge of the system. In this paper simulation results are also presented with and without fuzzy control to better understand the necessity of the fuzzy logic controller.**

*Keywords* – **DC-DC Converter, Fuzzy logic controller, PWM,**

## I.  INTRODUCTION

DC-DC buck converters are the circuits which reduce the voltage level from high level to low level. The conventional buck converters do this task by varying the duty cycle of the main switches like MOSFET or IGBT etc. As the buck converters are very efficient circuits when compared with the linear regulators, they are very much popular in the market now in a days. But the main problem is due to its switching characteristics, the control still poses a challenge for the designers and researchers.

The conventional control techniques available for controlling buck converter are Voltage mode control, current mode control and $V^2$ control. But there are some drawbacks associated with the conventional control techniques like compensation is very much difficult in voltage mode control, stability is a big issue in the case of current mode control, and circuit complexity will be very much difficult for $V^2$ control.

So there had been a search for other control techniques like sliding mode control, fuzzy control and PID control(PI or PD or combination of all) .PI and PID are the linear control techniques and Sliding mode control, fuzzy control and  artificial neural network control are the non linear control techniques.

This paper is organized as follows. Section II explains the theory of operation of the buck converter without fuzzy control and with fuzzy control. Section III explains the simulation results and Section IV gives the conclusion.

## II.  THEORY OF OPERATION

The circuit diagram of a buck converter is shown in fig 1. It consists of one active switch ( generally it will be a MOSFET or IGBT) , one passive switch (most of the times it will be a diode) , one inductor and one capacitor to reduce the ripple in the output voltage.
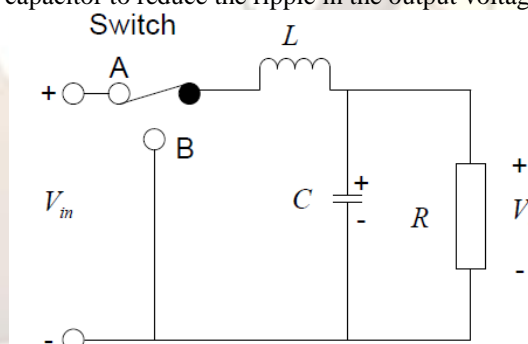


Fig 1: Circuit when the active switch is ON

In the circuit  when the input voltage is applied, the active switch is closed initially, and as the current through the inductor can't change suddenly, current will be developed gradually. After some time when the active switch is closed, because of the stored energy in the inductor, (diode will be in forward biased condition, there will be a closed path for the current stored in the inductor). it acts as current source and current through the inductor decreases gradually. Finally we will get saw tooth waveform for the current and the voltage. (Continuous mode of operation)
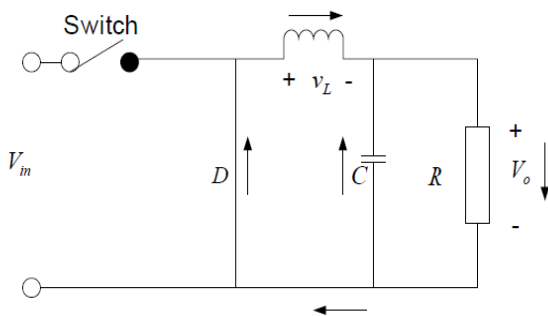
Fig 2: Buck converter circuit when the active switch is switched off.

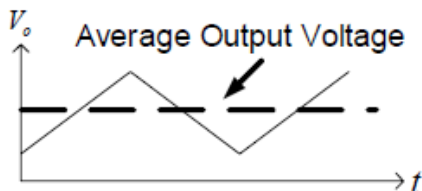The output waveforms of the voltage is



Fig 3: Output voltage waveform  with the presence of inductor..

Here the active switch is fired by using a pulse generator. But  with the conventional multiphase buck converter to get required output voltage , we have to calculate the required duty cycle and the appropriate inductor value etc. And another drawback is in open loop, even a small disturbance also causes a large variations.

So closed loop is very much preferred one. Here we had preferred fuzzy logic control. Fuzzy control is simply based on heuristic knowledge of the basic system. It is mainly based on the rules. And the main advantage is it does not require an exact mathematical model. It mainly involves fuzzification, knowledge base, rule editor and defuzzification.
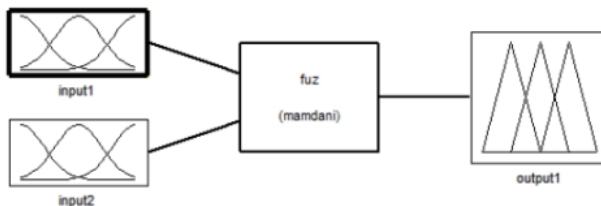
Fuzzification consists of two inputs

1.    Error
2.    Change in error

e[k]=Vo[k] – reference value

ce[k]=e[k]-e[k-1]. In the $K^{th}$ iteration

The two inputs are multiplied by scaling factors of gain and then fed into the fuzzy controller. The output of the fuzzy controller is the change in the duty cycle. The scaling factors can be tuned to obtain a satisfactory response.[1].

Fuzzification:



The first step is to assign the membership functions for the inputs. And output

They are as follows

For inputs of error and change in error are  Negative, Zero and Positive.

And for the output, they are  NB, NS, Z, PS and PB.

The number of fuzzy levels is not fixed and they can be varied depending upon the required resolution.

Second step in this process is Rule editor.

Rules for our buck converter will be like

|          | Negative | Zero | Positive |
|----------|----------|------|----------|
| Negative | NB       | N    | Z        |
| Zero     | N        | Z    | P        |
| Positive | Z        | P    | PB       |

Rules need not be in unique way. They can be varied as per the required output.

And the last step is defuzzification.

Defuzification can be done by Centroid method, Center of maxima, center of average etc. Generally Centroid method is preferred.

### III.  SIMULATION RESULTS

The  buck  converter  circuit  is  simulated  using MATLAB 2010. It had been simulated in both Open loop and with the fuzzy control technique to better understand the necessity of the fuzzy logic control technique.
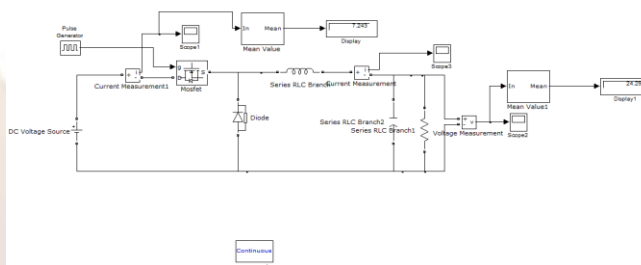


Fig  4:  Open  loop  buck  converter  simulated  in MATLAB
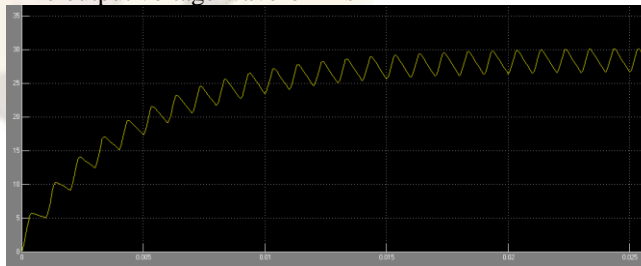
 The output voltage waveform is



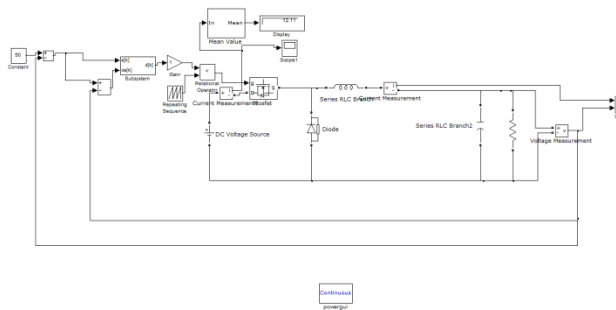Fig 5:Output voltage waveform for the circuit in Fig 4.

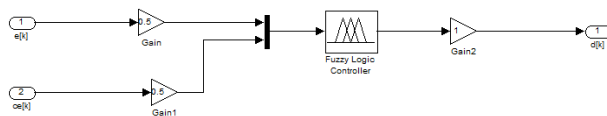Fig 6: Buck converter circuit by the use of fuzzy logic control



Fig 7: Subsystem for the circuit shown in Fig 6

Here we can clearly observe the use of fuzzy logic controller in the buck converter circuit.

And in the conventional buck converter we have to calculate the required duty cycle, in case of fuzzy logic controlled buck converter simply give double of the required voltage as reference. (If 10 v is needed, give 20 v as reference).
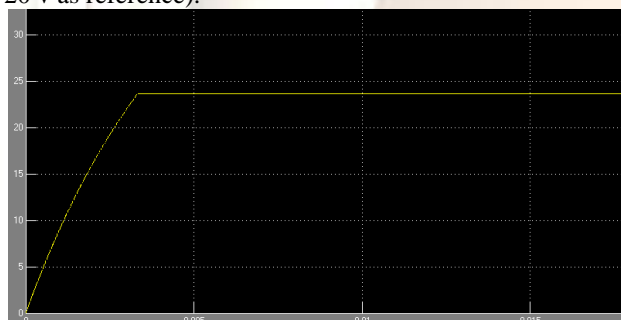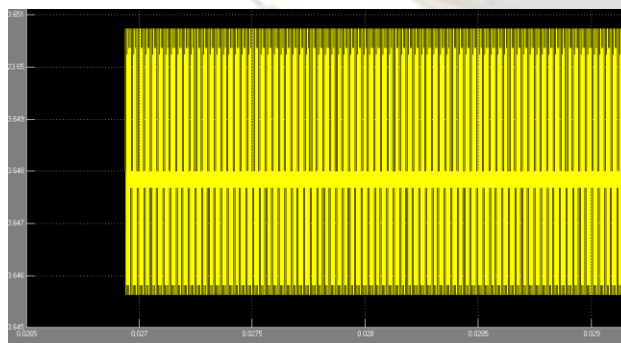


Fig 8: Output of the fuzzy logic controlled buck converter shown for the fig 6.



[10]

Fig 9: Output voltage across the load at steady state for the fuzzy logic controlled buck converter shown in the Fig 6

## IV.  CONCLUSION

A fuzzy logic controlled single phase buck converter is designed and verified by simulation results in the MATLAB and as per simulation results, the ripple in the output voltage had been reduced to 60mV by the use of fuzzy logic controller. And the efficiency of the buck converter is also up to the satisfactory limits during the operation.

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