International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-03, Issue-12, December 2016

In Push-Pull Converter Output Voltage Stability Comparison with Using Fuzzy Logic, PI and PID Controllers

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***Abstract*— Today dc converters are widely used in industrial applications. The research on DC converters are typically focused on determining the optimum switching method. In this study, a push-pull converter model arranged in MATLAB / Simulink digital environment, the output voltage in response, using with proportional integral control (PI) , proportional integral derivative control (PID) and fuzzy logic control (FLC) methods performance were examined. PI, PID and fuzzy logic control methods for MATLAB / Simulink environment necessary simulation models were constructed and compared the results in terms of stability and efficiency of these three approaches.**

***Index Terms*— push-pull converter, proportional integral control (PI), proportional integral derivative control (PID), fuzzy logic control (FLC), MATLAB / Simulink.**

I. Introduction

A dc - dc converters are widely used in regulated switch - mode dc power supplies and in dc motor drive applications. Often the input to the converters is an unregulated dc voltage, which is obtained by rectifying the line voltage, and therefore it will fluctuate due to changes in the line voltage magnitude[1].

DC-DC power electronics and control systems control technique and increase productivity in the art Although the issue tackled, mathematical analog control techniques such as the difficulty of modeling and hardware Disadvantages are available. Because the construction of the controller based on complex mathematical models of nonlinear systems is a major challenge [2].

This problem is solved with the discovery of the possibility of applying fuzzy logic in this area. Because fuzzy logic approach without the need of complex mathematical modeling has become a classic solution with digital controllers use and offer advantages in terms of hardware costs. Today, these problems fuzzy logic (FL) or proportional integral (PI) are trying to find solutions, such as the traditional controller. Speed of the PI controller and load changes in the vaccine and to cause volatility is undesirable [3].

DC-DC control techniques in power electronics and control systems and to increase efficiency of this technique is a subject dealt, despite the disadvantages of analog control techniques, such as the difficulty of mathematical modeling and hardware available. Because the controller is based on the construction of mathematical models of complex non-linear systems is an important problem in this area, the possibility of applying fuzzy logic discovery of this problem has been solved. Classical fuzzy logic approach because digital controller without the need to use complex mathematical modeling has become a solution to the advantages provided in terms of hardware cost. Nowadays these problems, fuzzy logic (FL), or proportional integral (PI) controllers as well as traditional tried to find a solution. Classical controllers are speed and load changes caused by the violation and are undesirable fluctuations [4].

Manuscript received May 30, 2016

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II. Push-Pull Converters

The Figure 1 represents the electronic schema of the proposed boost voltage converter using the push pull structure. The operation of push-pull converter: When Q_1 switches ON, current flows through the upper half of the T1 transformer primary and the magnetic field in T1 expands. The expanding magnetic field in T1 induces a voltage across the T_1 secondary; the polarity is such that D_2 is forward-biased and D_1 is reverse-biased. D_2 conducts and charges the output capacitor C_1 via L_1. L_1 and C_1 form an LC filter network. When Q_1 turns OFF, the magnetic field in T_1 collapses and after a period of dead time (dependent on the duty cycle of the PWM drive signal), Q_2 conducts, current flows through the lower half of T1's primary, and the magnetic field in T1expands. At this point, the direction of the magnetic flux is opposite to that produced when Q_1 conducted. The expanding magnetic field induces a voltage across the T1 secondary; the polarity is such that D_1 is forward- biased and D_2 is reverse-biased. D_1 conducts and charges the output capacitor C_1 via L_1. After a period of dead time, Q_1 conducts and the cycle repeats.

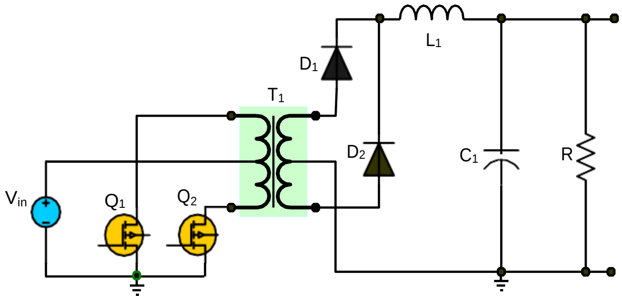

Fig. 1. Proposed DC/DC Push-pull converter

There are two important considerations with the push-pull converter:

• Both transistors must not conduct together, as this would effectively short circuit the supply. This means that the conduction time of each transistor must not exceed half of the total period (D < 0.5) for one complete cycle, otherwise conduction will overlap.

• The magnetic behavior of the circuit must be uniform; otherwise, the transformer may saturate, and this would cause destruction of Q1 and Q2.

This behavior requires that the individual conduction times of Q1 and Q2 must be exactly equal and the two halves of the center-tapped transformer primary must be magnetically identical. These criteria must be satisfied by the control and drive circuit and the transformer. The output voltage equals that of equation (1).

$$V_{out} = 2DV_{in}\frac{N_2}{N_1} \qquad (1)$$

Where: D is the duty cycle of the transistor, Q1 and Q2, 0<D<0.5[5].

III. Push-Pull Control Loop

The push-pull converter is controlled with a voltage mode control scheme. The PWM module is configured for Push-Pull mode with an independent time-base. The DC Link voltage is measured by the voltage sensors and sent to DSP control. This value is subtracted from the voltage reference in software to obtain the voltage error. The voltage error is then fed into a control algorithm that produces a duty cycle value based on the voltage error, previous error, and control history. The output of the control algorithm is also clamped to minimum and maximum duty cycle values for hardware protection. The voltage mode control algorithm must be executed at a fast rate in order to achieve the best transient response. Therefore, the control algorithm is executed in the ADC interrupt service routine, which is also assigned the highest priority in the UPS code [5]. A block diagram of the push-pull converter control scheme is shown in Figure 2.

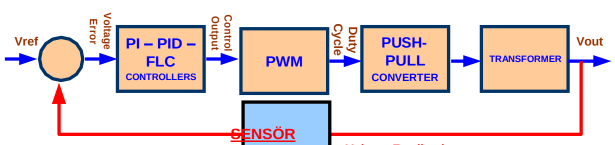

Fig. 2. A Block diagram of Push-pull voltage control loop

IV. Control Systems Models

In this study, push-pull converter circuit separately, PI, PID, and is controlled by the FLC. A DC inverter output voltage for a given input voltage, the value of the switch is controlled by setting the duration of the transmission and cutting. In these periods, Pulse Width Modulation (PWM) method is called is set. Fixed switching frequency PWM switching, switch control signal repetitive waveform shown in Figure 3 is obtained by comparing the signal level voltage Vk controls [6-7].DC inverters, the input voltage and output load are changed, even if the desired average value of the output voltage that is requested. It is designed for different control models. The most important of these is the PI, PID and Fuzzy Logic control. This control models desired, and comparing the actual voltage values are the error and the error change [8]. These two values form input control models. The output of the model is used for switching the PWM control voltage Vk. Control model, the inverter sets the value of the actual output voltage V_k in order to deliver the desired voltage.

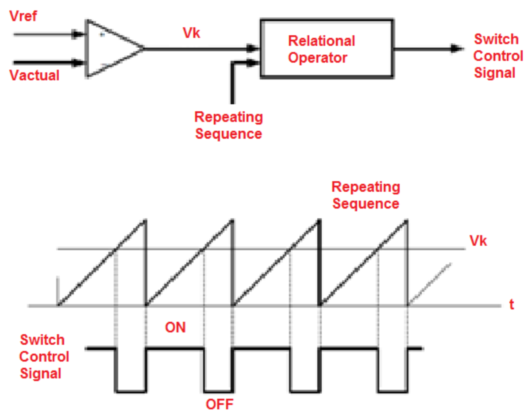

Fig. 3. Pulse Width Modulation (PWM)

A. *Proportional Integral (PI) Control Type*

The control block diagram of the classical PI controller is given in Figure 4. According to DC converter reference voltage input circuit, output voltage, is controlled by the PI controller. On activated equations are as follows. When you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables.

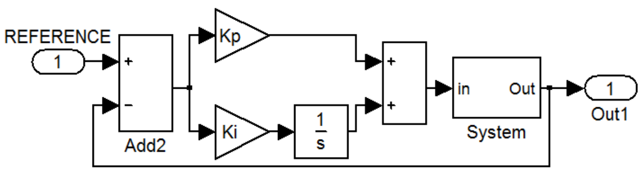

Fig. 4. PI Controller Block Diagram

B. *Proportional Integral Derivative (PID) Control Type*

The PID controller is the most common form of feedback. It was an essential element of early governors and it became the standard tool when process control emerged in the 1940s. The “textbook” version of the PID algorithm is described by equation (2).

$$u(t) = K\left(e(t) + \frac{1}{T_i}\int_0^t e(\tau)d\tau + T_d\frac{de(t)}{dt}\right) \qquad (2)$$

where y is the measured process variable, r the reference variable, u is the control signal and e is the control error ($e = y_{sp} - y$). The reference variable is often called the set point. The control signal is thus a sum of three terms: the P-term (which is proportional to the error), the I-term (which is proportional to the integral of the error), and the D-term (which is proportional to the derivative of the error). The controller parameters are proportional gain *K*, integral time T_i, and derivative time T_d [9].

C. Fuzzy Logic Control Type

The first is a small steam engine as the control for fuzzy logic control was carried out by Mamdani and Assilian. Fuzzy logic control algorithm consists of a set of rules and linguistic terms to express an intuitive control for fuzzy sets and fuzzy logic to evaluate the rules used [10-11].

As is known, the structure of fuzzy logic controller consists of three parts. If you need a brief look at these sections, the first as "The Blur" phase, the absolute values are converted to fuzzy values. Then, fuzzy rules, fuzzy values are processed "Rule processing and decision-making" phase, and finally, "defuzzification" step, the exact result is converted to fuzzy. Fuzzy logic control system is shown in Figure 5 [12-13].

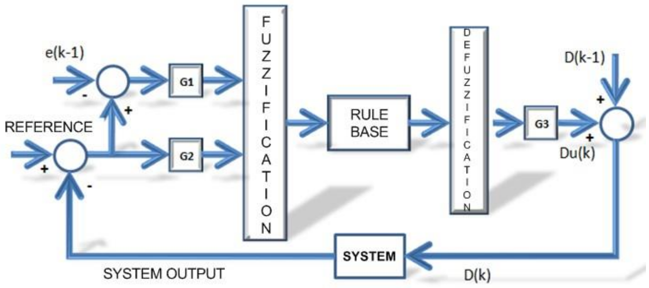

Fig. 5. FLC Controller Block Diagram

V. SIMULATION OF THE FULL SYSTEM

Figure 6 PI in the system, in turn, is connected to the PID and FLC. These controllers, variable speed error between the reference and the output signal audited by the push-pull converter is PMDC motor actual speed with PWM method determines the position of the MOSFET switch. Push-pull converter, determines the output voltage of the switch position. This voltage determines the speed of the motor.

VI. CONCLUSION

In MATLAB / Simulink programming, the variable reference voltage applied to PI, PID and fuzzy logic based control have been made, the push-pull converter output voltage PI was observed for PID and fuzzy controlled systems. Simulation results are shown in Figure 7, Figure 8 and Figure 9.

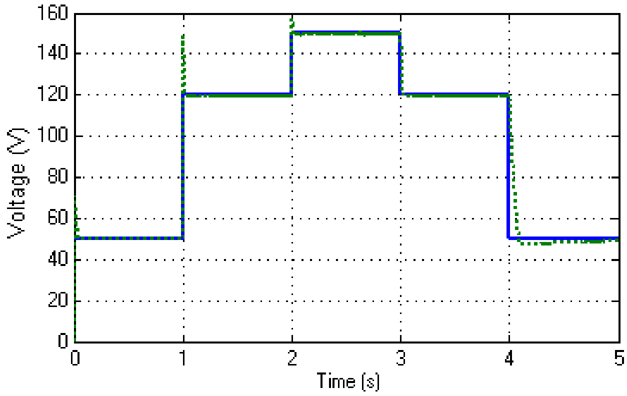

Fig. 7. Push-Pull converter with PI controller

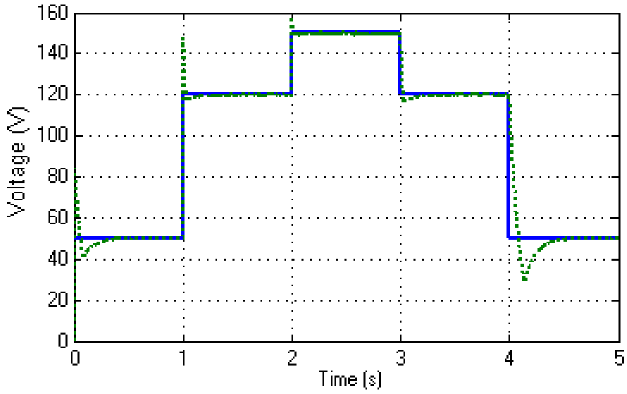

Fig. 8. Push-Pull converter with PID controller.

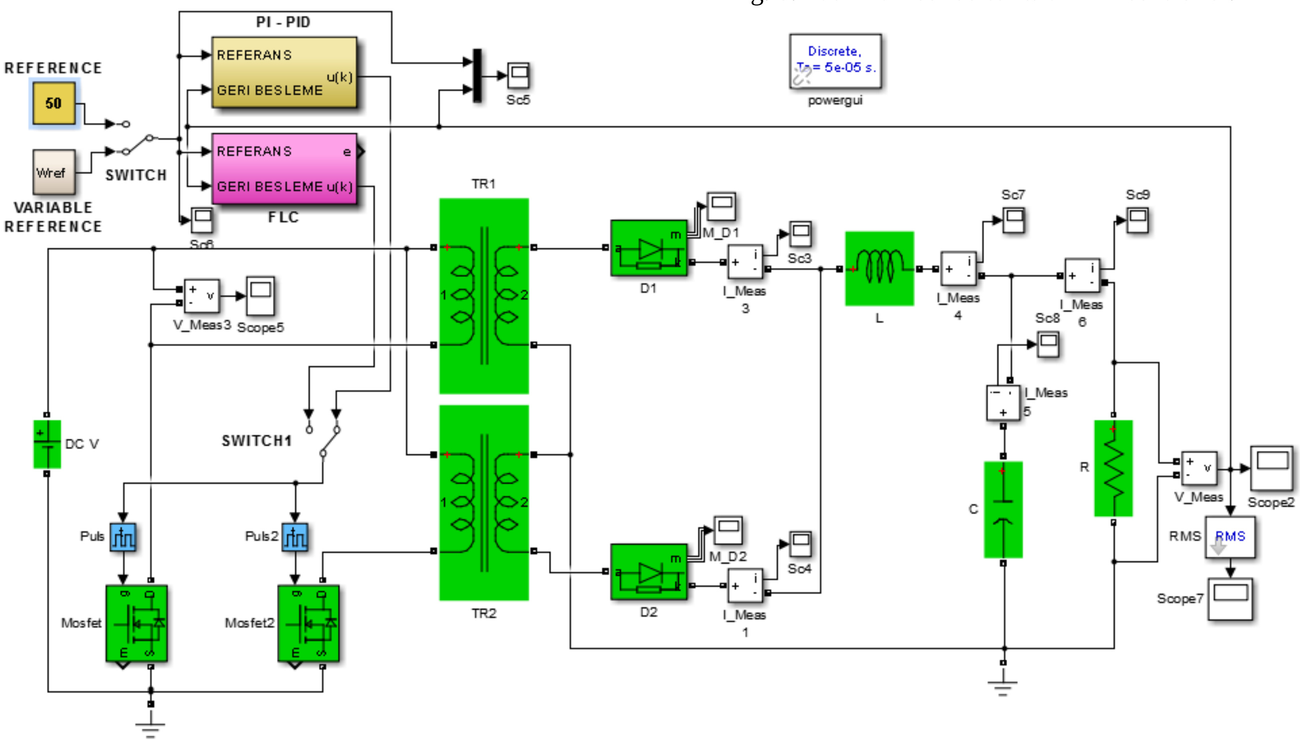

Figure 6. The block diagram of the whole system

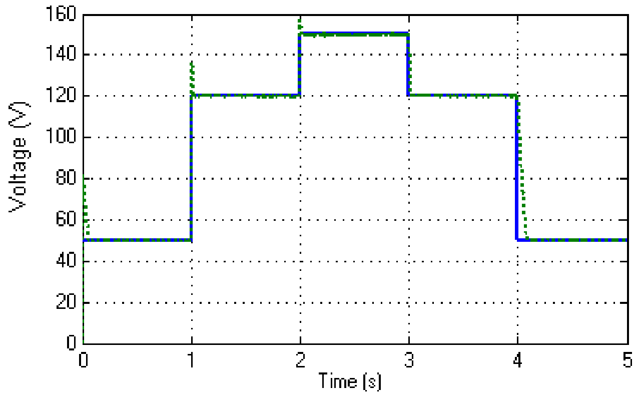

Fig. 9. Push-Pull converter with FLC controller

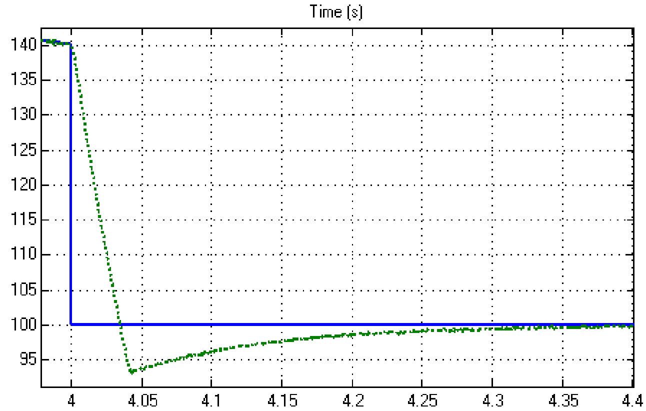

Fig.13. Variable reference detailed response of the PI cont.

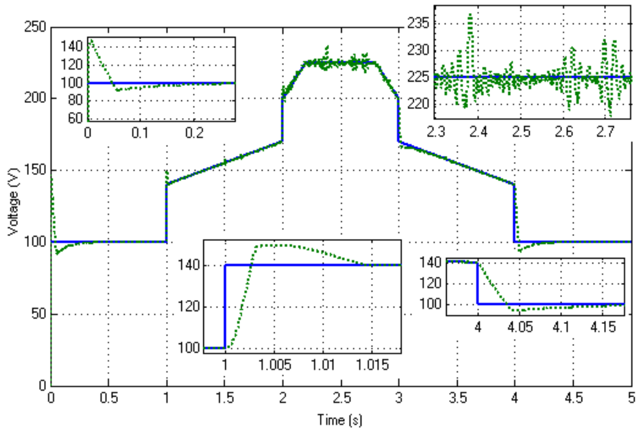

Fig.10. Variable reference of the PI controller, in response to a push-pull inverter output.

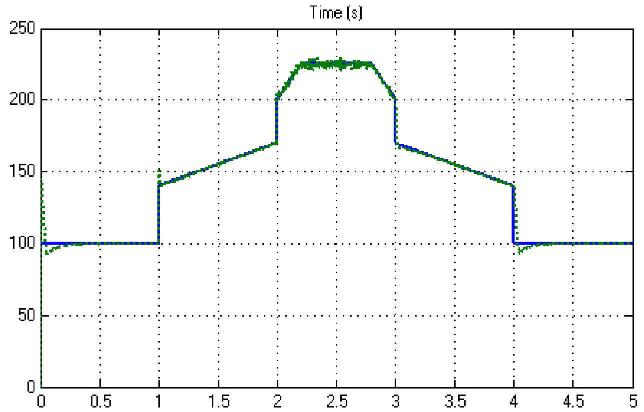

Fig.14. Variable reference of the PID controller, in response to a push-pull inverter output.

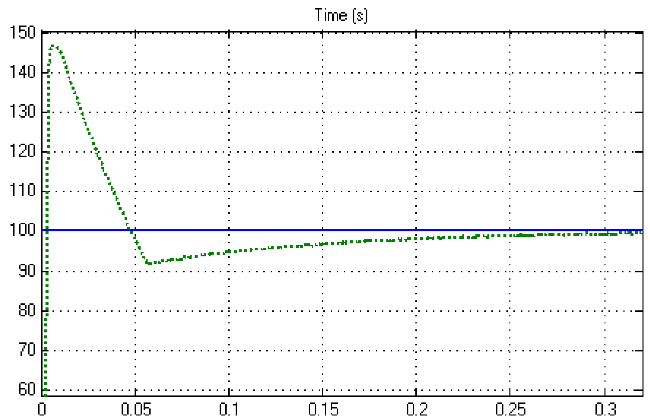

Fig.11. Variable reference detailed response of the PI cont.

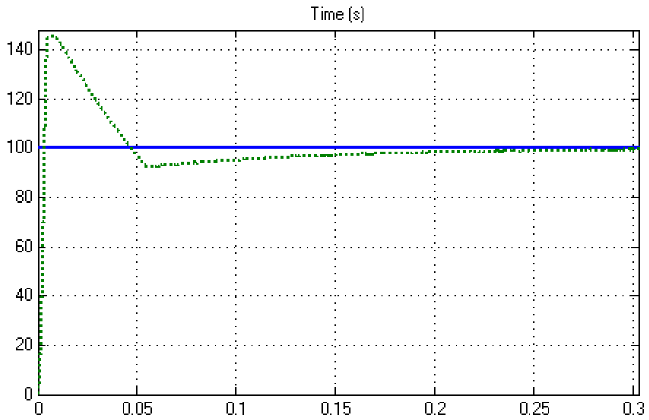

Fig.15. Variable reference detailed response of the PID cont.

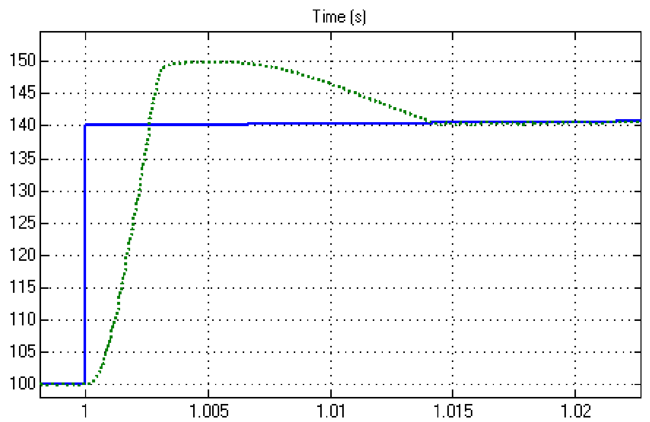

Fig.12. Variable reference detailed response of the PI cont.

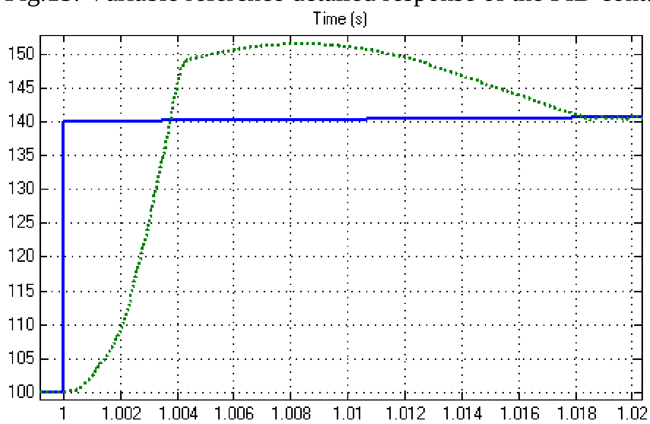

Fig.16. Variable reference detailed response of the PID cont.

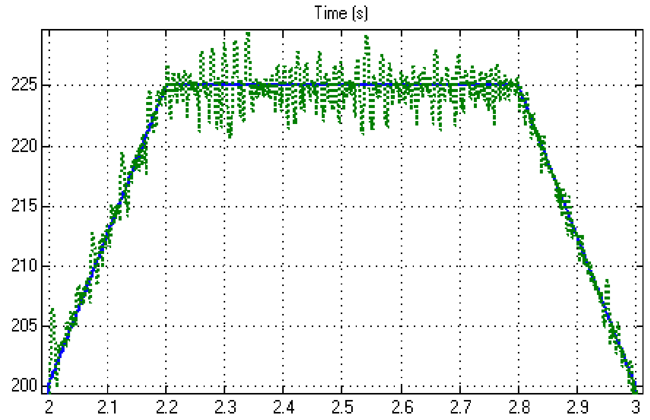

Fig.17. Variable reference detailed response of the PID cont.

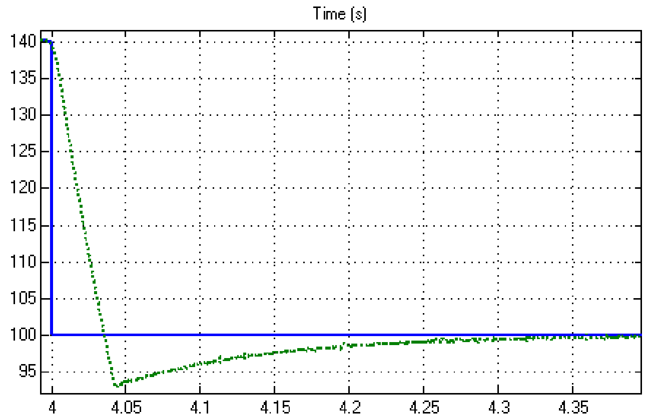

Fig.18. Variable reference detailed response of the PID cont.

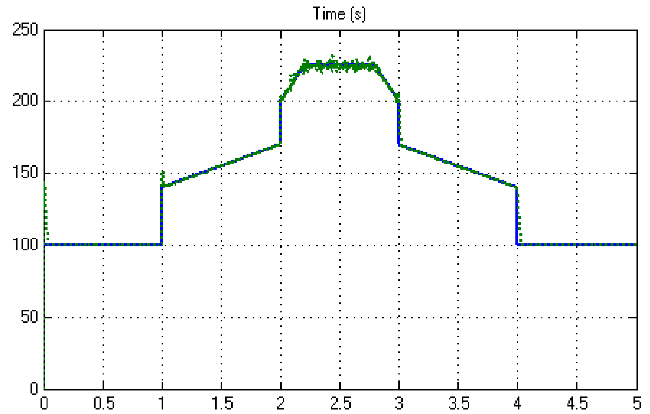

Fig.19. Variable reference of the FLC controller, in response to a push-pull inverter output.

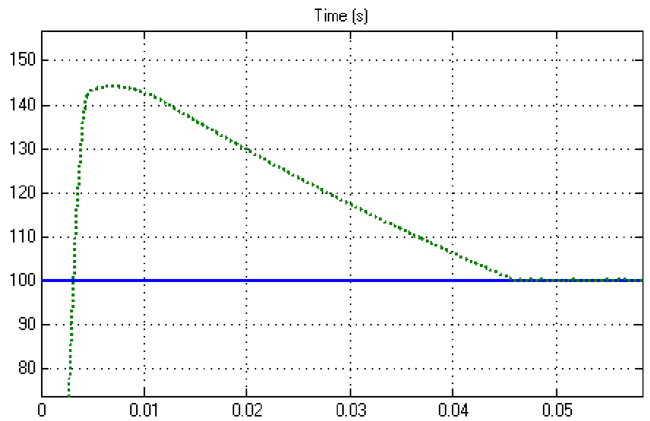

Fig.20. Variable reference detailed response of the FLC cont.

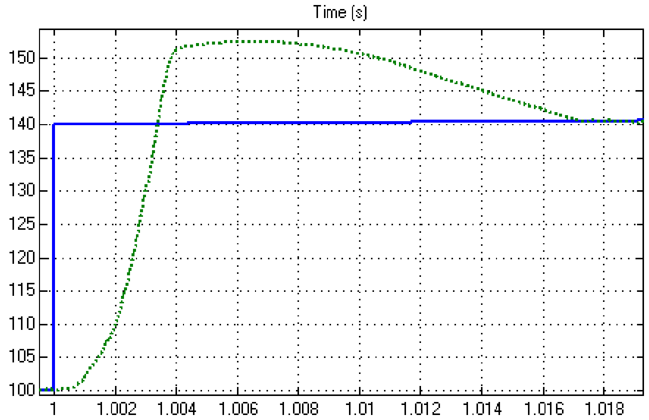

Fig.21. Variable reference detailed response of the FLC cont.

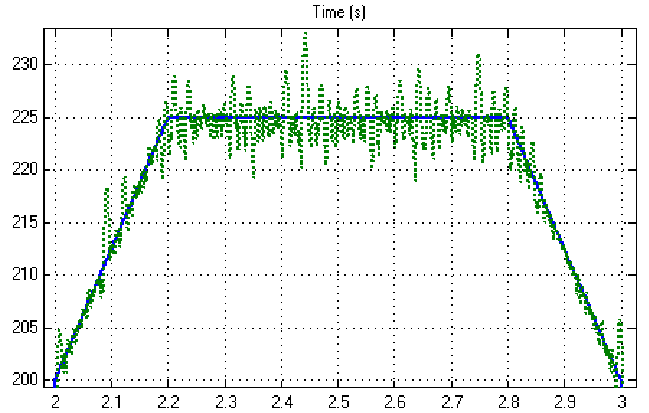

Fig.22. Variable reference detailed response of the FLC cont.

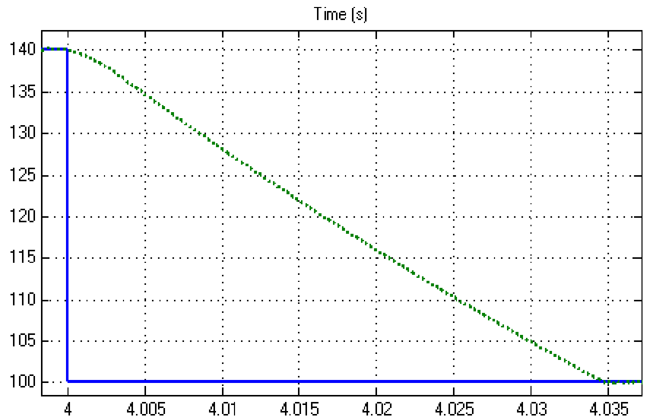

Fig.23. Variable reference detailed response of the FLC cont.

Considering the simulation results in PI and PID control model to overcome that seems to be a long time to reach the reference. The proposed fuzzy logic control models based on PI and PID control models in less time and without exceeding seen from the figures that reached the reference value. As a result of fuzzy logic control models it has been shown to give better results than this app PI and PID control models.

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