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Performance Analysis of Positive Output (P/O)Push-Pull Switched Capacitor Converter for High Power Density Applications

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Abstract: *The micro-power-consumption technique requires high power density DC/ DC converters and power supply sources. In this research, a PI and Fuzzy Logic Controllers for an elementary circuit of positive output (P/O) push-pull switched capacitor converter has developed for high powerdensity applications with high sustainability under enormous line and load disturbances. The voltage lift technique is a popular application in electronic circuit design. The power converter performs DC-DC step-up voltage conversion withhigh efficiency, high power density and cheap topology in a simple structure. The proposed converter combines both switched-capacitor and voltage lift techniques. Referable to thetime varying and switching nature of the power electronic converter their dynamic behavior becomes highly nonlinear. Conventional controllers are incapable of providing excellent dynamic performance and hence the fuzzy logic controller can be used as a feed forward controller for controlling powerelectronic converters. The control algorithm is developed to ensure tracking of the reference voltage and rejection of systemdisturbances by successive measurements of the converter output voltage at certain time instants within a conduction period. The simulation of PI and Fuzzy logic controls have been carried out using MATLAB/Simulink software to evaluate the controller's performances.*

Keywords: *Luo converter, DCDC converter, PI Controller,Fuzzy Controller.*

I.INTRODUCTION

In many PWM DC-DC converter topologies, the controllable switches are operated in switch mode where they are required to turn the entire load current on and off during each switching cycle. Under these conditions, the switches are subjected to high switching stresses and power losses. P/O Push-Pull switched capacitor converters are an alternative to PWM DC-DC converters. The operation of P/O Push-Pull switched capacitor converter is quite differentfrom the operation of PWM converters [1-9]. The minimum power-utilization performance needs far above the ground power concentration DC/ DC converters and power offer foundation. A voltage carry technique could be the standard submission of the electronic circuit style. A facility device performs DC-DC change of magnitude voltage translation with large potency, large power concentration and low cost module with an exceedingly straight forward arrangement. The target for this work is to develop PI and Fuzzy controllers for Elementary circuit of P/O Push-Pull switchedelectrical device converters to confirm stable load voltage underneath offer and cargo troubles mistreatment Simulink code. The simulation results are given and evaluated. Recently DC-DC convertors technique had expanded in topical years, it was needed for to achieve a large power concentration, large -voltage transport expand and large power potency.

Two-output DC-DC converters exchange a positive i/p supply voltage to positive and negative Vo. They incorporate2 translation ways, one is positive conversion path and also the different could be a negative conversion path. These parallel symmetrical double-o/p voltages were particularly needed on factory applications with boundary circuits like prepared amplifiers, boundary power provides, degree of difference servo drives with a fewproportioned voltage medical objects. To manage the o/p voltage of DC-DC convertors regardless of consignment differences and provide distractions, it's required to work theDC-DC convertors as control systems. Its PWM simulation management, the instruction of voltage output of DC-DC convertors are accomplish by variable the duty cycle for the electronic switch maintenance that frequency of functional invariable [10-13]. These converters generally have complicated non-linear models in to variation issues. PI and Fuzzy controllers are employed during that work of regulation the voltage output for above converters underneath offer and cargo interruptions. Tests for load parameter and line parameter are dispensed with gauge controllers' recitals. The consequences were given and tested.

II. P/O PUSH-PULL SWITCHED CAPACITOR (PPSC) CONVERTER

A. Basic Circuit of P/O PPSC Converter

The Basic circuits and corresponding circuits throughoutswitch-on , switch-off were show in Fig.2.1 switches S and S1 function in PPSC mode . Fig2.2 shows the equivalent circuit during S on and fig.2.3 shows the Equivalent circuit during S on S1 on. The potential difference throughout condenser C1 is incriminated to Vin through output on. A voltage throughout condenser C2 is incriminated to VO = 2Vin throughout flip. Thereafter, the output voltage was, thinking the voltage drops throughout a switches and diodes,to mix every charges during a picture of ΔV1. The important voltage output was

$$V_o = 2V_{in} - \Delta V_1$$

$$= 2V_{in} - (V_{D1} + V_s + V_{S1} + V_{D2})$$

$$= 2V_{in} - (2V_s + 2V_d)$$

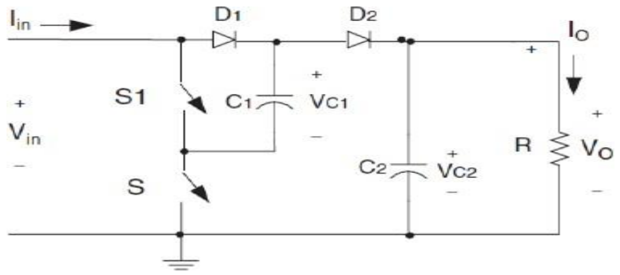


Fig.2.1 Basic diagram of P/O-Circuit

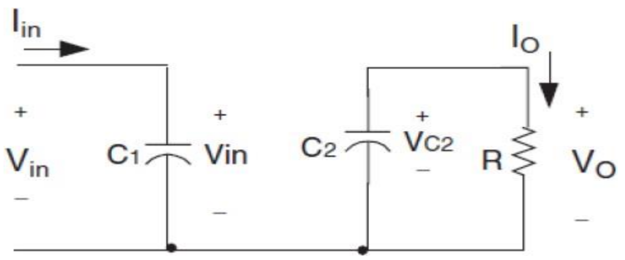


Fig.2.2 Equivalent circuit during S on

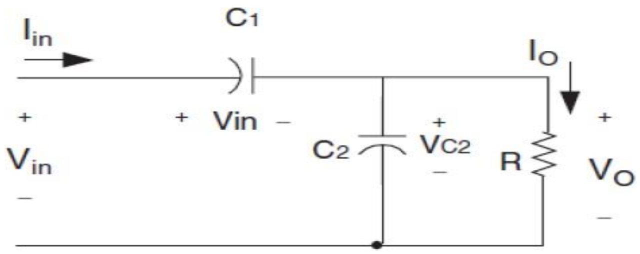
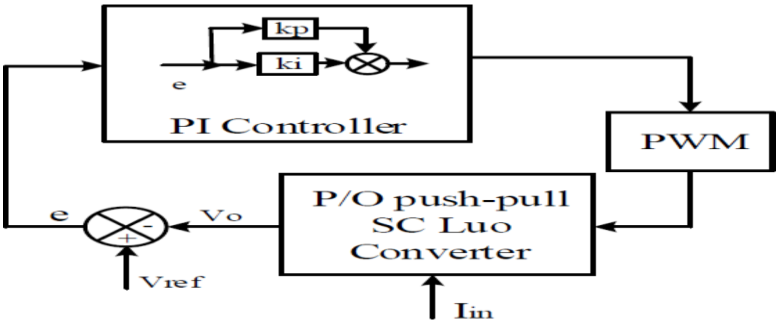


Fig 2.3.Equivalent circuit during S on S1 on

B. Design of Conventional Controllers

PI managements are used for many decades in industries for method control applications. The explanation for his or her wide quality lies within the simplicity of style and sensible performance together with low share overshoot and tinysubsidence time for slow method plants .The most appreciated feature of the PI controllers is their relativeeasiness of use, as a result of the 3concerned parameters have a transparent physical that means. This makes their calibration potential for the operators additionally by trial and error and in any case, an oversized range of tuning rulesare developed. Although all the prevailing techniques for the PI controller parameter standardization perform well,endless and an intensive analysis work remains current towards system management quality improvement and performance enhancements. A PI controller was basically a common control system pointer methods. In rule was this it supervises the mistake connecting a computed method changeable and a preferred set point; from that error, a counteractive signal was calculated and was ultimately feedback to the input facet with regulate a method consequently. It equation with the PI controllor was as follows, Thus, the PID management algorithmic rule isdelineates with the burdened add for thrice occupations werethe 3 different burdens are Proportional gain establishes the authority into current mistake worth of the control methods, integral gain come to a decisions the feedback supported to realm beneath the mistake time camber up to a current purpose explanations for the coverage of the response to the speed for modification of the mistake with period. The structure



for PI controller was shown in Fig.2.4.

Fig.2.4 Structure of PI controller

C. **Design of Fuzzy logic Controllers**

The Fuzzy Logic Controller (FLC) provides an adaptivecontrol for better system performance. Fuzzy logic is aimed to provide solution for controlling non-linear processes and to handle ambiguous and uncertain situations. Fuzzy controlis based on the fundamental of fuzzy sets. The fuzzy control for the chosen converter is developed using input membership functions for error 'e' and change in error 'ce' and the output membership function for D, the duty ratio of converter. GE and GC are the gain factors of the error and change in error respectively, which are defined as

e * GE = Vr-Vo ce * GC= e k-e k-1

where Vr is the reference or the desired output voltage and Vo is the actual output voltage. The subscript 'k' denotes values at the beginning of kth sampling cycle. The duty ratioof the converter will be determined by the fuzzy inference. For instance, if the output voltage continues to increasegradually while the current is low during the charging process, the fuzzy controller will maintain the increase in voltage to reach the set point. A drop in the output voltage level triggers the fuzzy controller to increase the outputvoltage of the converter by modifying the duty cycle of the converter. The resolution of fuzzy logic control system relies on the fuzziness of the control variables while the fuzziness of the control variables depends on the fuzzinessof their membership functions. Fuzzy control involves three stages: fuzzification, inference or rule evaluation anddefuzzification as shown in Fig.2.5 P/O Push-Pull switched capacitor converters is modeled using Matlab software. Fuzzy control is developed using the fuzzy toolbox. The fuzzy variables 'e', 'ce' and 'D' are described by triangular membership functions. Seven triangular membershipfunctions are chosen for simplicity and Table I shows the fuzzy rule base created in the present work based on intuitive reasoning and experience. Fuzzy memberships NB,NM, NS, ZE, PS, PM, PB are defined as negative big,negative medium, negative small, zero and positive small, positive medium and positive big. The block diagram for fuzzy logic controller for chosen converter is shown in Fig.2.

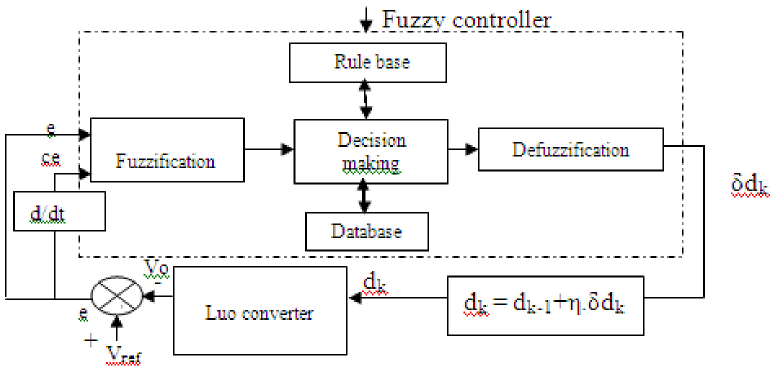


Fig.2.5 Block diagram of fuzzy control for P/O Push-Pull switchedcapacitor converters

TABLE I.
Fuzzy Rule Base

e \ ce	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

III.MODULE SIMULATION RESULTS OF P/O PPSCCONVERTER

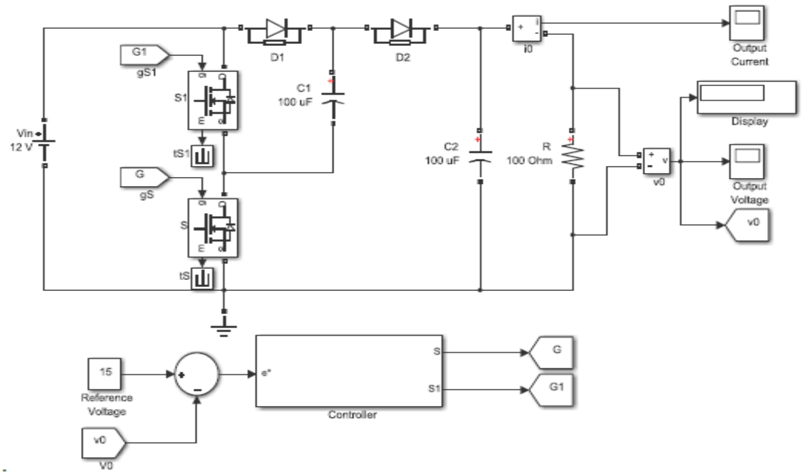


Fig. 3.1 Closed Loop of Basic Circuit of P/O -PPSCConverter

Table II.
Statement of Circuit Parameters –P/O Ppsc Converter

Variables	Statement
V_i	12V
Vo	15 V
R_L	100 Ω
Fs	20KHZ
Capacitance (C & C_1)	100 µF
Duty range	0.05 to 0.95

A. Conventional Controllers

Fig.3.1 shows the control system reply of initial of the voltage output and current wave for Elementary Circuit of P/O Push-Pull SC converter device with point 15V and nominal load 100Ω with PI controller. Fig.3.2 shown the simulated voltage output and current wave of Elementary Circuit of P/O Push-Pull SC converter device with explosiveline disturbances thanks to offer decrement. The Fig.3.3shows the servo response with twentieth decrement from set voltage at time t=0.06 sec. (t =0 – 0.06 sec, V= 15 V, t=0.06-0.12 sec, V= 12 V, twentieth decrement). The Fig.3.4shows the servo response with twentieth increment from setvoltage at time t = zero.16 sec (t =0.12 – 0.16 sec, V= 15 V, t=0.16 -0.24 sec, V= 18 V, twentieth increment. thesimulated voltage output and current wave in BasicCircuit of P/O PPSC device with explosive loaddisturbances. The Fig.3.5 shows the response withincrement and decrement of fifty load of t =0 – 0.06sec, Vo= 15 V, R = one hundred ohm; t=0.06 -0.12sec, V= 15 V, R = one hundred fifty ohm; t=0.12 –0.16 sec, V= 15 V, R = one hundred ohm; t= 0.16 –0.24 sec, V= 15 V, R = fifty ohm; t=0.24 – 0.35 sec,V= 15 V, R = one hundred ohm.

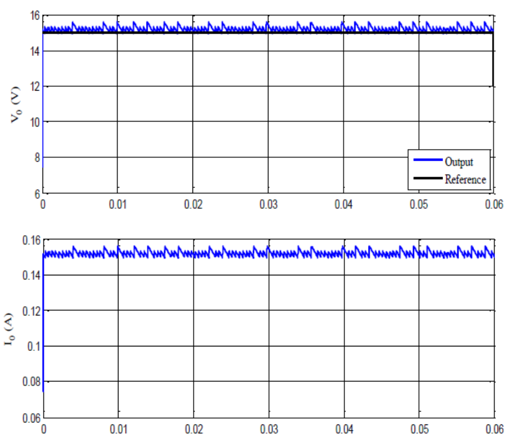


Fig. 3.2 Simulated start-up of the Vo and current wave of Basic Circuit ofP/O PPSC converter with point 15V and nominal load 100Ω.

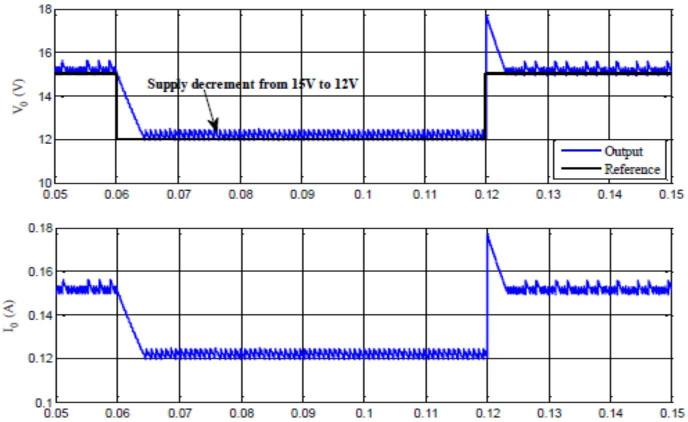


Fig. 3.3 Simulated Vo and current wave form of Basic Circuit of P/O PPSCdevice with unforeseen line disturbances (15V-12V-15V)

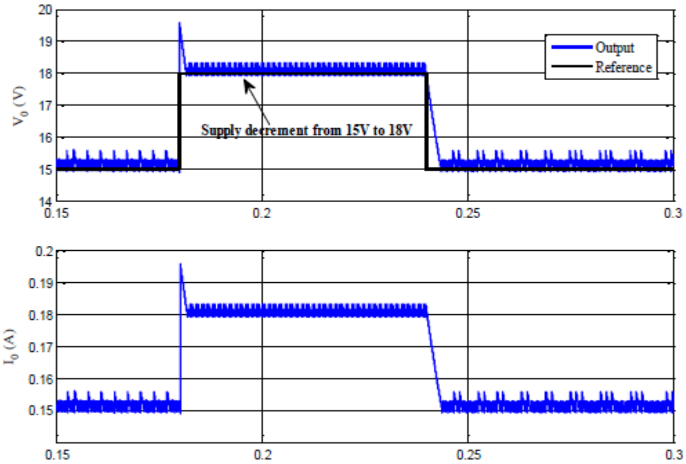


Fig. 3.4 Simulated Vo and current wave form of Basic circuit of PPSCconverter with unforeseen line disturbances (15V-18V-15V)

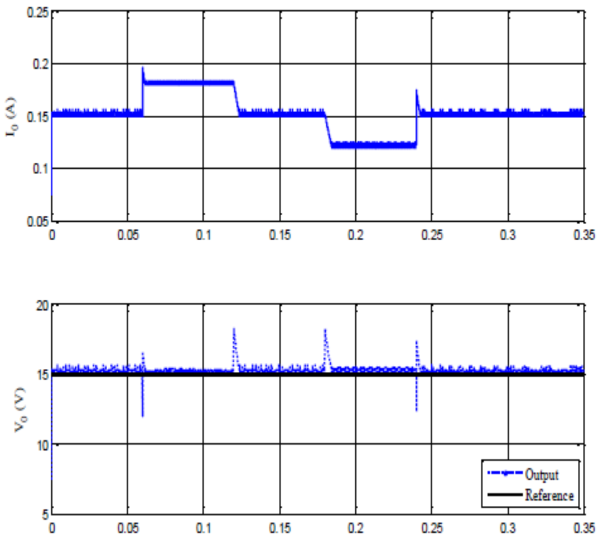


Fig. 3.5 Simulated output voltage and current undulation of Basic Circuit of P/O PPSC device with unexpected load disturbances (100Ω –50 Ω - 100Ω)

B. Fuzzy Logic Controllers

Fig.3.1 shows the control system reply of initial of the voltage output and current wave for Elementary Circuit of P/O Push-Pull SC converter device with point 15V and nominal load 100Ω with Fuzzy controller. Fig.3.6 shown thesimulated voltage output and current wave of Elementary Circuit of P/O Push-Pull SC converter device with explosiveline disturbances thanks to offer decrement. The Fig.3.7shows the servo response with twentieth decrement from set voltage at time t=0.06 sec. (t =0 – 0.06 sec, V= 15 V, t=0.06-0.12 sec, V= 12 V, twentieth decrement). The Fig.3.8shows the servo response with twentieth increment from setvoltage at time t = zero.16 sec (t =0.12 – 0.16 sec, V= 15 V, t=0.16 -0.24 sec, V= 18 V, twentieth increment. the simulated voltage output and current wave in Basic Circuitof P/O PPSC device with explosive load disturbances. TheFigs 3.9 and 3.10 shows the response with increment anddecrement of fifty load of t =0 – 0.06 sec, Vo= 15 V, R =one hundred ohm; t=0.06 -0.12 sec, V= 15 V, R = one hundred fifty ohm; t=0.12 – 0.16 sec, V= 15 V, R = onehundred ohm; t= 0.16 – 0.24 sec, V= 15 V, R = fifty ohm;t=0.24 – 0.35 sec, V= 15 V, R = one hundred ohm. Fig.3.11shows the graphical representation of performancevaluation of controllers for Basic Track of P/O PPSCConverter using MATLAB

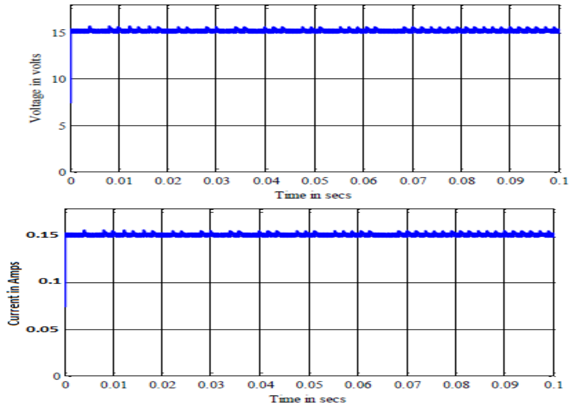


Fig. 3.6 Simulated start-up of the Vo and current wave of Basic Circuit ofP/O PPSC converter with point 15V and nominal load 100Ω.

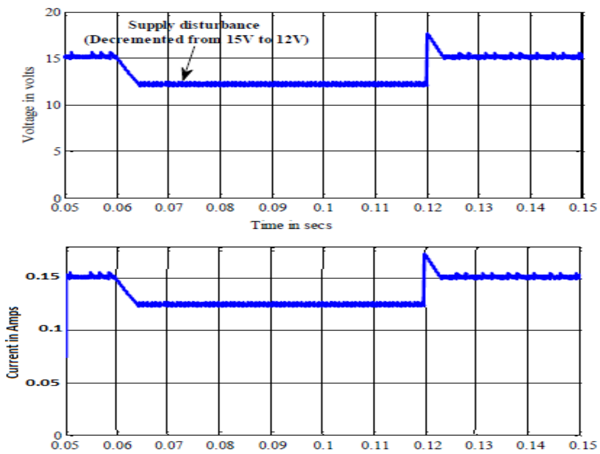


Fig.3.7 Simulated Vo and current wave form of Basic Circuit of P/O PPSCdevice with unforeseen line disturbances (15V-12V-15V)

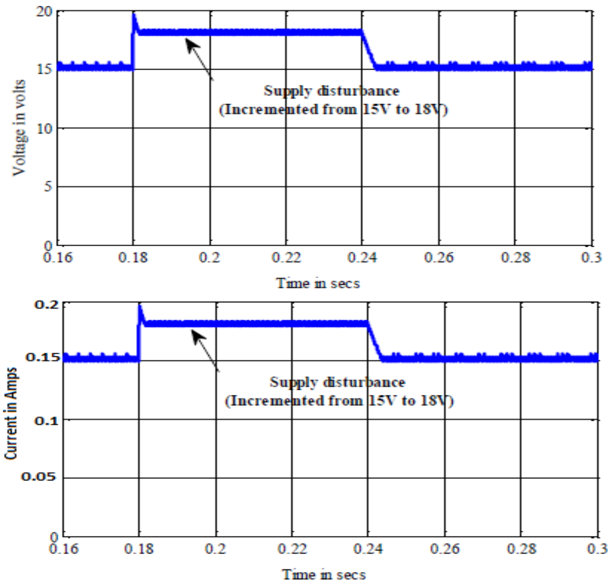


Fig. 3.8 Simulated Vo and current wave form of Basic Circuit of P/O PPSCdevice with unforeseen line disturbances (15V-12V-15V)

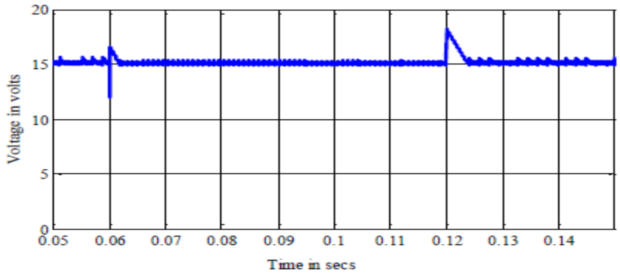


Fig.5.15 Simulated Vo with load disturbances (100Ω –90 Ω -100Ω)

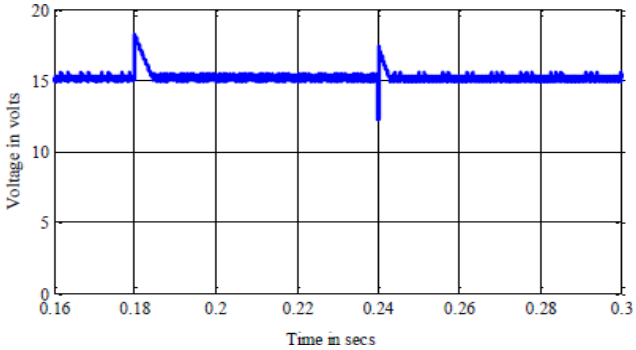


Fig.3.9 Simulated Vo with load disturbances (100Ω –110 Ω -100Ω)

Table III.
Performance Evaluation of P/O Ppsc Converter With Resistive Load Using Matlab

Controller				Servo Response				Regulatory Response			
	Start-up transient			Supply change (15V-12V-15V)		Supply change (15V-18V-15V)		Load change (100Ω-90Ω-100Ω)		Load change (100Ω-110Ω-100Ω)	
	Peak over shoot	Rise time (ms)	Settling time (ms)	Peak overs hoot	Settling time (ms)	under shoot	Settling time (ms)	Peak over shoot	Settling time (ms)	under shoot	Settling time (ms)
PI	-	-	1.5	-	5.7	7.94	3.0	10	3.6	20	7.5
Fuzzy	-	5.0	0.9	-	0.5	-	1.8	-	2.4	-	1.5

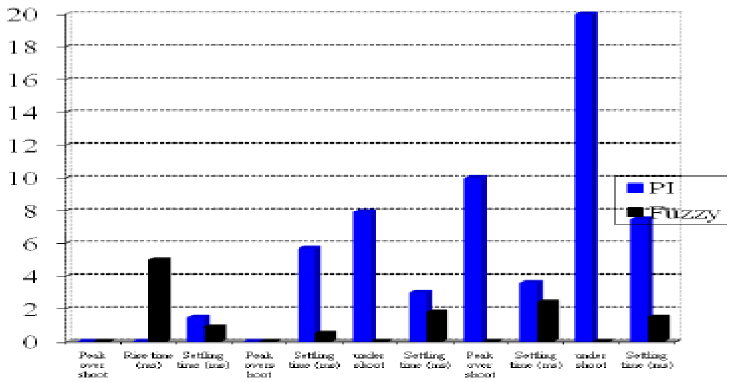


Fig.3.11 Graphical representation of performance evaluation of controllers for Basic Track of P/O PPSC Converter using MATLAB

V. CONCLUSION

The Simulation results show that the proposed PI and fuzzy controller regulates satisfactorily the output voltage of of p/o ppsc converter with resistive load irrespective of line and load disturbances. These establish the validity of the proposed fuzzy controller that effectively rejects changes in DC supply voltage and load resistance which achieving fast tracking of the converter output voltage.

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