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# Control of Phase Shift Series Resonant Dc To Dc Converter Using GA Tuned Fuzzy Proportional Integral Controller

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## Abstract

In current electrical world, numerous applications are based on dc to dc switching converters. In this paper, how the steady state and transient response of phase shift series resonant dc/dc converter is enhanced using genetic algorithm tuned fuzzy proportional integral controller under starting and load step change conditions is reported. The main target of using the controller is to regulate the output voltage under the dynamic load condition. The model of the genetic algorithm tuned fuzzy proportional integral is implemented using Sim Power Systems toolbox of MATLAB SIMULINK. Step load change condition performance is also investigated and is reported here.

**Key Words:** Genetic Algorithm, proportional integral Controller, Phase Shift Series Resonant dc/dc converter, dynamic response

## Introduction

Recent days power distribution system for mobility applications are done by power electronic systems. Plenty of power converters revels the dynamic characteristics [1]. Normally continuous control under goes from as a minimum of one of the subsequent conditions, i. difficult to control due to plenty of components, ii. Vulnerability to noise, more heat, component life reduced, iii. Parameter alteration procedures were difficult. Due to these conditions we couldn’t get the minimal overshoot [2]. In order to improve the dynamic response of boost dc-to-dc converter, voltage-mode control and the current-mode control was used. But the voltage recovery time when step load change took place was high [3]. Preceding that buck dc-to-dc converter was controlled by voltage mode control. But the recovery time when dynamic load condition and ripple voltage was high [4]. Jong-Jae Lee et al introduced a dual series-resonant active-clamp dc–dc converter; they obtained good efficiency and dynamic response. But ripple voltage was not reduced [5]. In order to maintain the constant voltage across load when changing, the different current mode control was used in PWM dc to dc converter in [6]. By the use of the different current mode controllers ripple voltage was reduced, even though the recovery time was not reduced. So as to reduce the recovery time plenty of techniques were implemented like monolithic converters [7]. Recovery time was reduced a lot, but ripple voltage was increased. To improve the dynamic performance of the dc to dc converter GA based PID controller was introduced [8]. But still the ripple voltages were not reduced. Preceding that controller, dynamic evolution control was proposed to control the dc to dc converter in dynamic load condition [9]. The ripple voltage was reduced a lot. But over shoot and under shoot voltages at the time of step load change was increased. So the dynamic performance was affected by overshoot and under shoot voltages. With the intention of improving the dynamic performance of the dc to dc converter, DAC pulse width modulator with sleep controller was introduced [10]. But the ripple voltage was increased when the step load change took place. In continue with that control feedback control theory was introduced to control the dc to dc converter [11]. But the dynamic performance was not improved. To increase the transient response and dynamic response of the converter the linear–nonlinear control was adopted in [12]. Even though that controller, the ripple voltages were not reduced. With the purpose of reducing ripple voltages, mixed-signal peak current mode control in low-power dc–dc converters in [13]. But the under and overshoot voltages was high. So as to improve the step load condition performance of dc to dc converter, complementary PID controller to passivity-based nonlinear control was used in [14]. But ripple voltage and recovery time in dynamic load condition was high. In order to improve the dynamic performance of the half bridge DC–DC converter, Pole placement and PID controller was used in [15]. But the transient voltage and ripple voltage were high. To reduce ripple voltage and obtain a fast response discretized sliding mode (DSM) controller used in dc-dc buck converter [16]. But the recovery time and overshoot voltage during step load change condition were increased. In order to improve the dynamic performance of phase shift resonant converter, different techniques were implemented such as soft switched phase-shifted full-bridge (PSFB) dc–dc converter [17]. But ripple voltage was not yet reduced.

In this paper phase shift series resonant converter which is shown in figure 1 is controlled using GA tuned Fuzzy proportional integral Controller. Due to the proposed control scheme, the DC to DC converter gives low ripple at output. It is likely to produce constant voltage while there is step change in load. In this paper, Section II deals with the phase shift series resonant dc to dc converter theory, Section III describes the significance of fuzzy logic controller, Section IV genetic algorithm used in the proposed topology, Section V shows the simulation results. Section VI concludes this paper.

## Phase Shift Series Resonant Converter

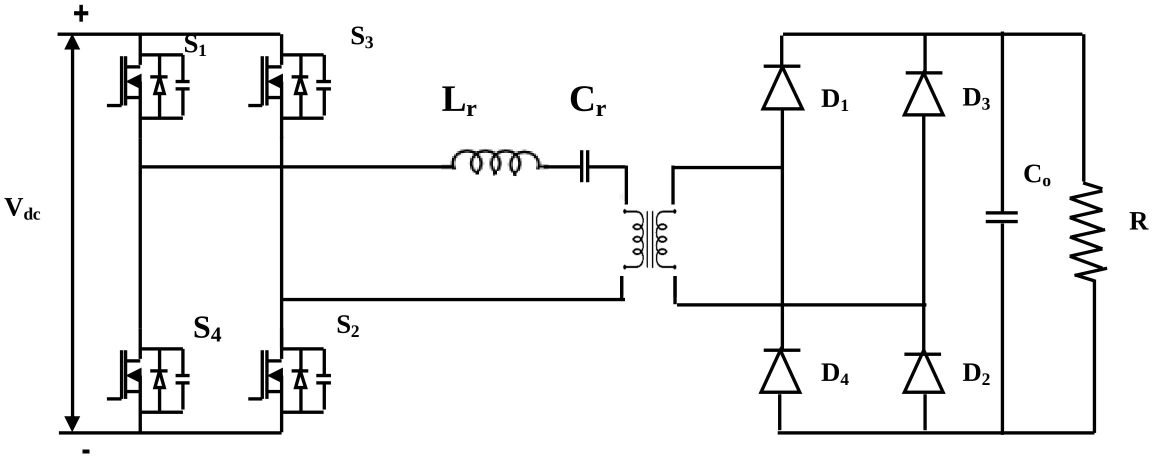

**Figure 1:** Phase Shift Series Resonant Converter

Figure 1 shows the circuit diagram of phase shift series resonant converter. The resonant components are inductor $L_r$ and capacitor $C_r$. The quasi square wave voltage which is fed to the resonant components is controlled by the firing angle α. The switching frequency $f_s$ is fixed and the firing angle α is varied. The resonant tank is described by its resonant frequency and denoted by $f_r$.

$$f_r = \frac{1}{\left(2\pi\sqrt{L_r C_r}\right)} \tag{1}$$

In order to get a good sinusoidal resonant current, the switching frequency is selected near the resonant frequency.

## FUZZY In Proportional Integral Control

Fuzzy controller can be replacing proportional integral with gains. This estimates the gain values that depend on the error. When we use a Pulse Width Modulation there is a chance to occur a chattering. Here pulse width is tuned by using a fuzzy proportional integral control. The duty cycle is adjusted along with the change of boundary layer by reason of the rule base. So as to diminish the chattering the gains should be varied. While we adjust the gains, the parameters settling time and transient time will be affected. In order to convince all these constraints the sliding mode fuzzy controller is tuned [18]. Consequently, the membership function is shown in figure 2. The entire rule base of this sort of fuzzy sliding mode controller might get the subsequent form:

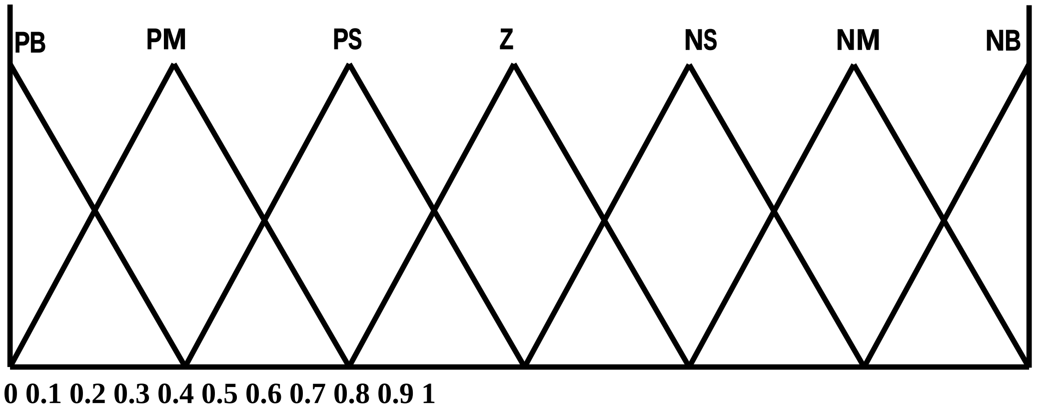

**Figure 2:** Membership Functions

If (s is PB) then (U is NB)
If (s is PM) then (U is NB)
If (s is PS) then (U is NM)
If (s is Z) then (U is NM) (2)
If (s is NS) then (U is PM)
If (s is NM) then (U is PB)
If (s is NB) then (U is PB)

## Genetic Algorithm

In this paper the essential key factors for fuzzy PI controller design are optimized by Genetic Algorithm. In PI controller the gains is optimized by Genetic Algorithm. Holland developed the optimization technique named as Genetic Algorithm (GA). Genetic algorithm has the special features such as; works with a coding of the constraint set it does not look for from a single point like conventional algorithms and it uses fitness function in sequence [19].

The following steps as [20] are used to optimize the gains of the genetic algorithm tuned Fuzzy SMC,

Step 1: Construct a population of initial solution of parameters (gains in Fuzzy SMC). Each constraint in the problem is called as a gene. A Chromosome includes genes and thus every chromosome is a solution to the problem.

Step 2: Assessment of objective function. In this problem, error ie the voltage deviation from the reference is to be diminished. For each chromosome, the MATLAB model is simulated and output voltage is computed.

Step 3: Estimation of fitness function. Normally the objective function is the fitness function.

Step 4: Production of offspring: Offspring is a new chromosome got through the steps of selection, crossover and mutation.

After computing fitness of every chromosome, parent solutions are selected for reproduction. It imitates the survival of the fittest mechanism in nature. Following the selection of parent population, crossover and mutation are performed to generate offspring population. The crossover and mutation are carried out based on the probability of crossover and mutation.

Step 5: Replace the current population with the new population.

Step 6: Terminate the program if termination criterion is reached; else go to step2.

## Simulation Results and Analysis

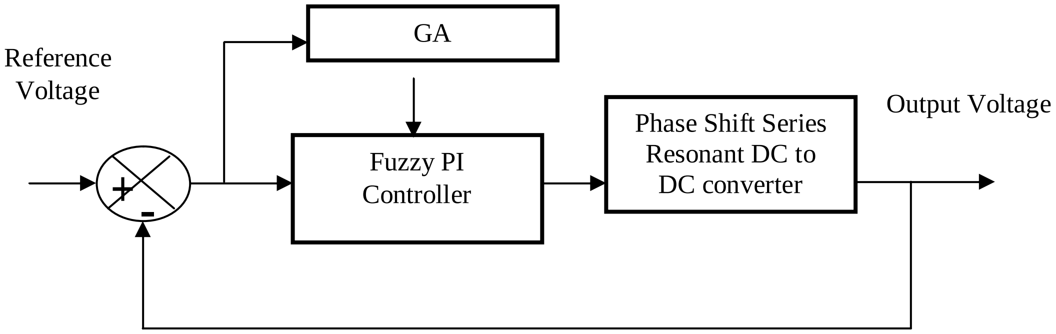

**Figure 3:** Simulation block diagram of the Phase Shift Series Resonant DC to DC converter using GA tuned Fuzzy Proportional integral control

The SIMULINK toolbox in the MATLAB software in order to model and test the dynamic response of Phase Shift Series Resonant DC to DC converter using GA tuned Fuzzy Proportional Integral Controller. Simulation parameters are listed in table 1.

**Table 1:** Simulation parameters of Phase Shift Series Resonant DC to DC converter

| **Parameter** | **Value** |
|---|---|
| Snubber Capacitor ($C_s$) | 3.3 nf |
| Resonant Inductor ($L_r$) | 560 µh |
| Resonant Capacitor ($C_r$) | 5 µf |
| Output Capacitor ($C_o$) | 99 mf |
| Switching Frequency | 33 KHz |

With rule base (2) the simulation of GA tuned fuzzy proportional integral controller based series resonant converter was carried out in MATLAB. The parameters of the phase shift series resonant DC to DC series converter are chosen to simulate according to table 1. Genetic algorithm was used to optimize the control gains which were used in the simulation of phase shift series resonant dc to dc converter using GA tuned Fuzzy proportional integral controller.

Simulating the Phase shift series resonant DC to DC converter by considering an input voltage has given as 150 V. The Phase shift series resonant dc to dc converter has been given 270 V output using fuzzy proportional integral controller gains which are tuned using genetic algorithm. The load has been changed from 50 Ω to 25 Ω at 0.2 sec. As shown in figure 4, the voltage is maintained as constant when load current changes. Ripple voltage of phase shift series resonant DC to DC converter is shown in figure 5. From figure 5, it is proven that GA tuned fuzzy sliding mode controller reduces the ripple voltage. Due to quick optimization of gains which are in fuzzy SMC using genetic algorithm, the ripple voltage phase shift series resonant DC to DC converter is considerably reduced.

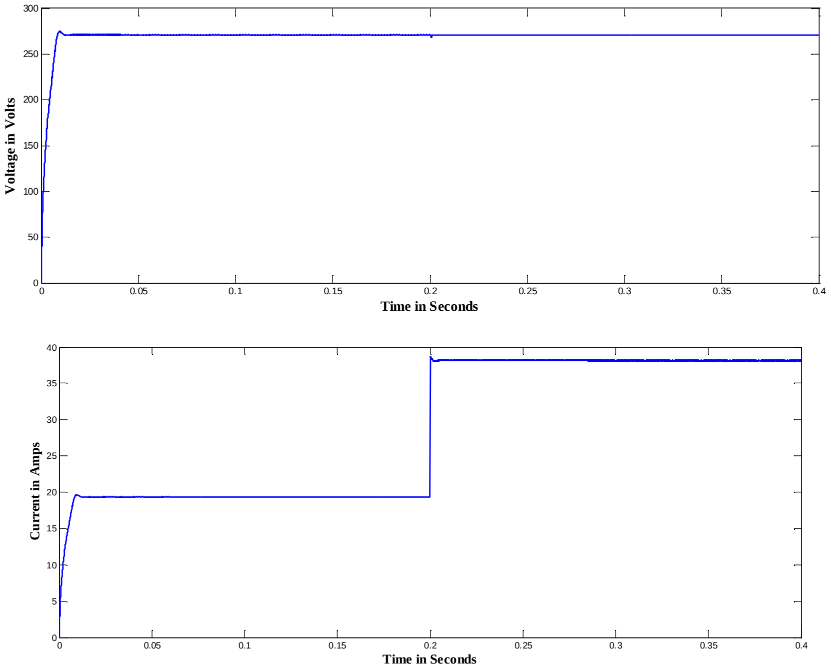

**Figure 4:** Output voltage and Current waveform of GA tuned fuzzy PI controlled Phase shift series resonant dc to dc converter at load change of 50 Ω to 25 Ω

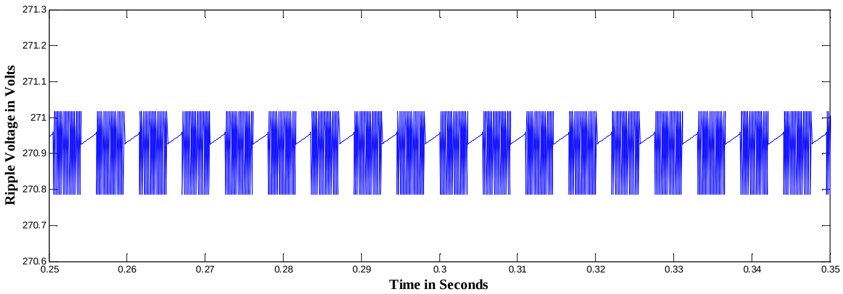

**Figure 5:** Ripple voltage of GA tuned fuzzy PI controlled phase shift series resonant DC to DC converter

## Conclusion

In this paper, a new configuration namely phase shift series resonant DC to DC converter using GA tuned fuzzy proportional integral controller is proposed. The proposed topology has low ripple voltage at output. The proposed topology is capable of fully protecting the phase shift series resonant DC to DC converter during load changes. Because of the genetic algorithm, tuning the over shoot and ripple has been eliminated. The MATLAB/Simulink based simulation results confirm that the ripple voltage and recovery time during load changes and transient time, have been absolutely improved.

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