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Comparative Analysis of Resonant SEPIC Converter with PI and Fuzzy Controller

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Abstract: Nowadays, for several Power Electronic appliances the control systems are increasing wide. Crucial with these demands of the client, several researchers or designers are troubled to search out the reliable and most economic controller to fulfill these demands. Modern power electronics applications expect low power converters to realize very high power density and high potency. The implementation and loss analysis of the SEPIC with the new design are provided in details. This paper determines the performance of SEPIC device using PI controller and fuzzy controller. For coming up with and verifying the results of a fuzzy controller, PI controller ought to conjointly use. The experimental results of the planned SEPIC device with fuzzy controller are evaluated as compared with results of PI controller. The comparison of each, the results indicates that the fuzzy controller is ready to get higher subsiding response than PI controller.

Key words: SEPIC Converter・Resonant Dc-Dc converter・PI Controller・Fuzzy Controller

INTRODUCTION

Basically two different control techniques are applied to dc-dc converters; they are PI-controller and fuzzy controller. Fuzzy control technique is a nonlinear control technique, whereas PI- control technique is a linear technique used for varied industrial applications. Generally, to see the amplification, cross-over frequency, gain margin and therefore the phase margin, bode plot is employed. Phase margin is employed to see the steadiness of the projected system. However PI controllers will solely designed for one nominal operative purpose of the system. Because the small signal model of the SEPIC device varies, the operative point varies. Each the poles and a right-half plane are unit zero and conjointly the magnitude of the frequency response are dependent on the duty cycle [1]. Therefore, for PI controller it's terribly tough to retort the changes in operative purpose. This technique incorporates a nonlinear dynamic behavior, because it add switch -mode.

In this paper we tend to analyse the equations of a SEPIC device and propose a simulation of DC/DC SEPIC device. Controller implementation is comparatively easy and willguarantee a small-signal response as quick and stable as alternative normal regulators and an improved large-signal response.

Principle of Operation: The SEPIC converter is able to either increase or decrease an input voltage by controlling the Duty Cycle of a pulse to the MOSFET. One way to do that is to directly control the Duty cycle using a potentiometer. There are some applications for which this control method is suitable but it is insufficient for many other applications. In order to drive the MOSFET, a pulse is needed. A 555 timer is used to produce a square wave with a set frequency and a Duty cycle$\geq$50%.

However, the duty cycle from the 555 cannot be easily changed without switching resistors. In addition, the SEPIC requires a duty cycle below 50% to buck the voltage when the input voltage is low. The pulse width will need to be modified separately from the 555 because the 555 cannot change or produce a duty cycle less than 50%. First a resistor and a capacitor are used in low pass to produce a triangle wave from the square wave output of the 555. Afterwards, this is sent to the negative pin of a comparator.

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The positive pin of the comparator receives a controlled voltage signal. Whenever the controlled voltage is greater than the triangle wave, the comparator will output voltage and otherwise it will be off. The greater this signal, the greater the duty cycle of the comparator output will be. One way to control this signal is to step down voltage using a potentiometer. Luckily, this signal can be kept in the same range as the triangle wave by using the same input that drives the 555 timer.

The duty cycle will not change when the input or the output voltage changes which means there is full control of how much the SEPIC steps up or down the voltage. This has both advantages and disadvantages for the circuit. Full control of the circuit can be useful.

The potentiometer allows the SEPIC to output a wide range of voltage from a wide range of input. This could be useful in battery applications 11 that need to run on various levels of power. One example would be a flashlight with adjustable brightness. This SEPIC converter could allow it to run on a large range of power with greater efficiency than simply reducing the voltage with a potentiometer to control the output.

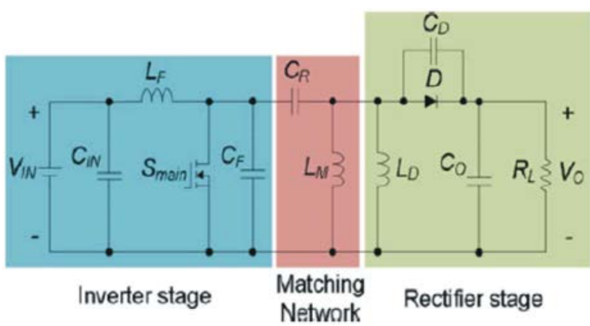

Fig. 2.1: Resonant SEPIC Converter

However, this control method does have its drawbacks. Most applications of the SEPIC converter control the voltage automatically. The problem with relying on controlling the input for circuit control is that there is no circuit feedback. When using a potentiometer, the only way to maintain the correct output is to watch the output and adjust accordingly. Visual feedback is only useful in certain circumstances. Usually it is best to use the SEPIC converter to hold a single output without the need for control when using a SEPIC as part of a large circuit.

Most battery operated circuits require dc-dc conversion to maintain full operation. In most circumstances that require stepping up and down the input voltage, SEPIC converters are worth the price of the extra inductor and capacitor for the efficiency and stable operation they provide [2]. While this project does go into detail about simulation results for the SEPIC converter, the physical potentiometer controlled SEPIC converter built was unsuccessful. Additionally, a cost benefit analysis to determine peak efficiency with the cheapest cost for the inductors and capacitors was never done.

But in PWM controller used SEPIC converter system that is difficulty of determining the Amplitude of the Current Source Injected into the Rectifier Stage. As well as in High-Order Resonant Tank design of the matching Network and Inverter Stage.

PI Controller: DC-DC conversion technology has been developing very rapidly and DC-DC converters have been widely used in industrial applications such as dc motor drives, computer systems and communication equipment's. The output voltage of Pulse Width Modulation (PWM) based DC-DC converters can be changed by changing the duty cycle. The Single Ended Primary Inductor (SEPIC) is a series of DC-DC converters possessing high-voltage transfer gain, high power density; high efficiency, reduced ripple voltage and current. These converters are widely used in computer peripheral equipment, industrial applications and switch mode power supply. Control for them needs to be studied for the future application of these good topologies [3]. The SEPIC increases the voltage transfer gain stage by stage in geometric progression.

However, their circuits are complex. An approach, SEPIC converters, that implements the output voltage increasing in geometric progression with a simple structured have been introduced. These converters also effectively enhance the voltage transfer gain in power law.

Due to the time variations and switching nature of the power converters, their static and dynamic behavior becomes highly non-linear.The design of high performance control for them is a challenge for both the control engineers and power electronics engineers. In general, a good control for DC-DC converters always ensures stability in arbitrary operating condition. Moreover, good response in terms of rejection of load variations, input voltage variations and even parameter uncertainties is also required for a typical control scheme. With different state-space averaging techniques, a small signal state-space equation of the converter system could be derived.

The PI control technique offers several advantages compared to PWM control methods: stability, even for large line and load variations [2], reduce the steady error, robustness, good dynamic response and simple implementation. Intensive research in the area of DC-DC converter has resulted in novel circuit topologies.

These converters in general have complex non-linear models with parameter variation. The averaging approach has been one of the most widely adopted modeling strategies for switching converters that yields a simple model. Analysis and control design of paralleled DC-DC converters with master-slave current sharing control has been well reported here.

In this project, state-space model for Single EndedPrimary Inductor Converter (SEPIC) are derived at first. A PI control with zero steady state error and fast response is brought forward. The static and dynamic performance of PI control for SEPIC converter is done in MATLAB/SIMULINK. Details on operation, analysis, control strategy and simulation results for SEPIC are presented in the subsequent sections.

A Operation of Pi Controller: For the purpose of optimize the stability of SEPIC converter dynamics, while ensuring correct operation in any working condition, a PI control is a more feasible approach. The PI control has been presented as a good alternative to the control of switching power converters. The main advantage PI control schemes is its insusceptibility to plant/system parameter variations that leads to invariant dynamics and static response in the ideal case [4].

Single-Ended Primary-Inductor Converter (SEPIC) is a type of DC-DC converter allowing the voltage at its output to be greater than, less than, or equal to that at its input. The output of the SEPIC is controlled by the duty cycle of the control transistor. A SEPIC has a advantages of having non-inverted output, using a series capacitor to couple energy from the input to the output and thus can respond more gracefully to a short-circuit output and being capable of true shutdown.

When the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge. SEPICs are useful in applications in which a voltage can be above and below that of the regulator's intended output. As with other switched mode power supplies, the SEPIC exchanges energy between the capacitors and inductors in order to convert from one voltage to another. The amount of energy exchanged is controlled by switch S, which is typically a transistor like MOSFET, IGBT etc. MOSFETs offer much higher input impedance and lower voltage, do not require biasing resistors [5]. MOSFET switch is controlled by differences in voltage rather than a current.

Fuzzy Logic Controller: Primarily 2 completely different control techniques are applied to dc-dc converters, they're pi-controller and fuzzy controller. Fuzzy control technique is a non-linear control technique, whereas pi- control technique is a linear technique used for numerous industrial applications. Generally, to determine the loop gain, cross-over frequency, gain margin and therefore the phase margin, bode plot is employed. Phase margin is employed to work out the stability of the planned system. However pi controllers will solely designed for one nominal operative purpose of the system. Because the small signal model of the SEPIC convertor varies, the operative purpose varies. Each the poles and a right-half plane are zero and conjointly the magnitude of the frequency response, are all dependent on the duty cycle.

Normally, SEPIC convertor has non-linear properties, as a result of of its properties, fuzzy controllers have been applied. Once fuzzy controllers are applied much in individual, it's such a lot of disadvantages despite of its appropriate characteristics. For dominant a SEPIC convertor, fuzzy controller was proposed [6]. Although, it's disadvantages however it has conjointly its own benefits that are suited for the control design. For coming up with and supportive the results of a fuzzy controller, pi controller ought to conjointly use. The experimental results of the planned SEPIC convertor exploitation fuzzy control are evaluated compared with results exploitation pi controller. The comparison of each the results indicates that the fuzzy controller is ready to get higher settling response than pi controller. The voltage level will increase or decreases counting on the utmost power. Moreover, the controller changes the voltage level by ever-changing the duty cycle of the heartbeat width-modulated (PWM) signal that tracks the reference signal. A curved reference signal is compared with the signaling to provide a purportedly zero error signal [7]. Another reference signal is employed to match the SEPIC's output, to realize the utmost power. This reference signal is adaptational, ever-changing its form in step with atmospheric condition.

Simulation Diagram and Results

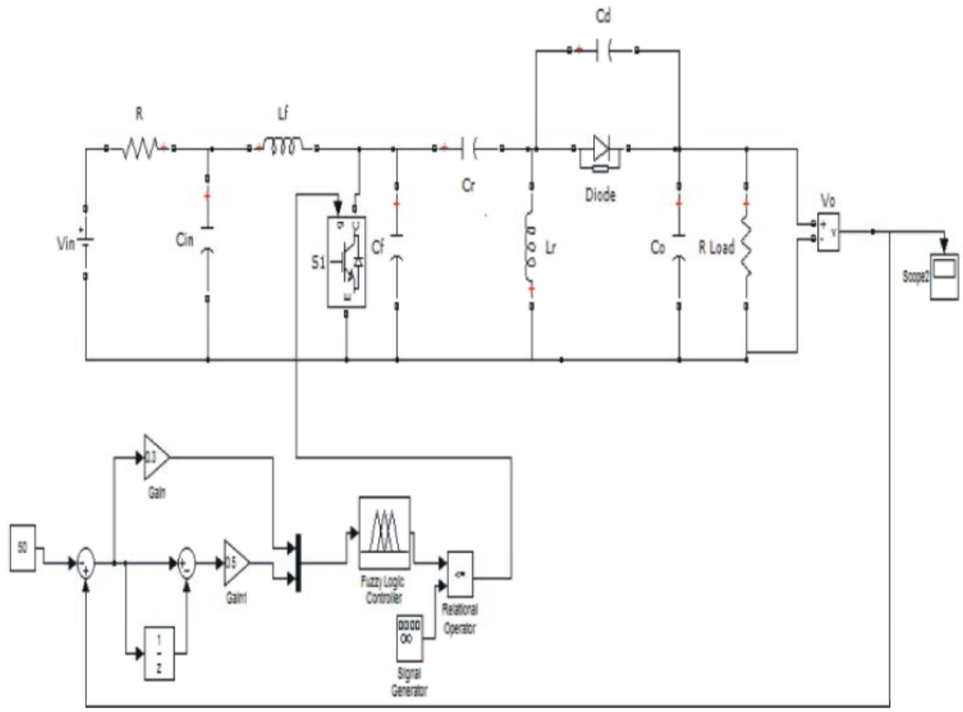

Fig. 5.1: Simulation diagram with Fuzzy Controller

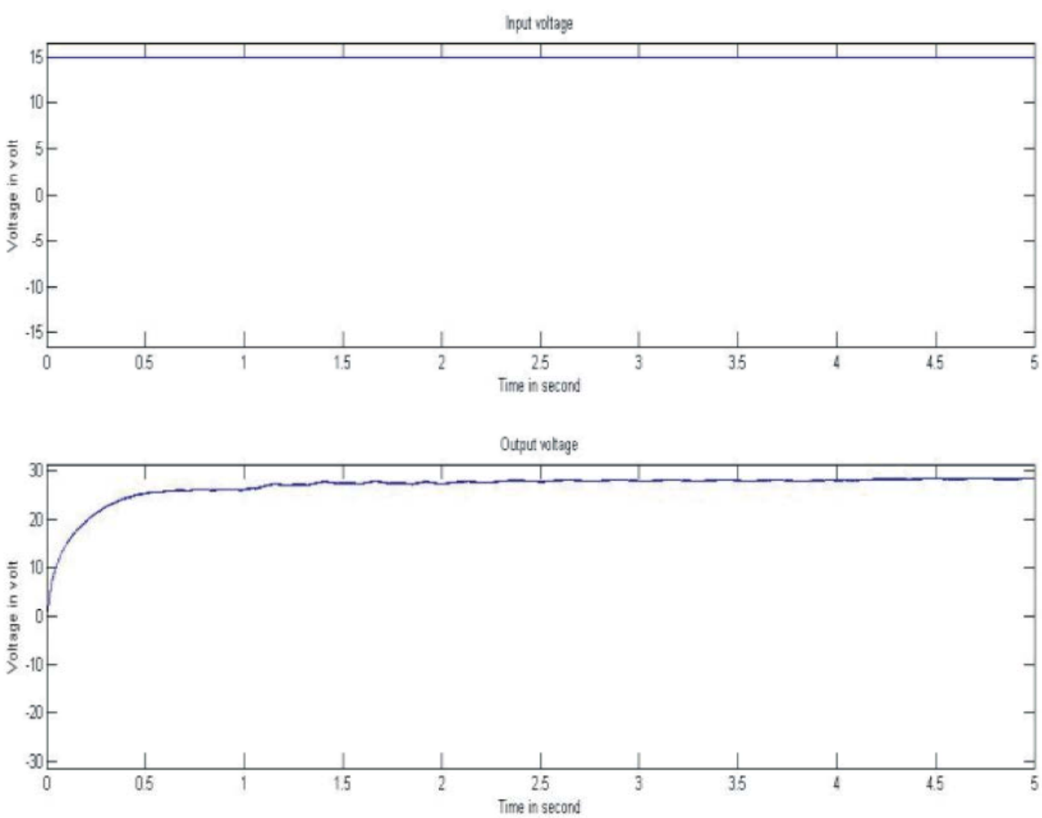

Fig. 5.2: Simulation results with PWM Controller

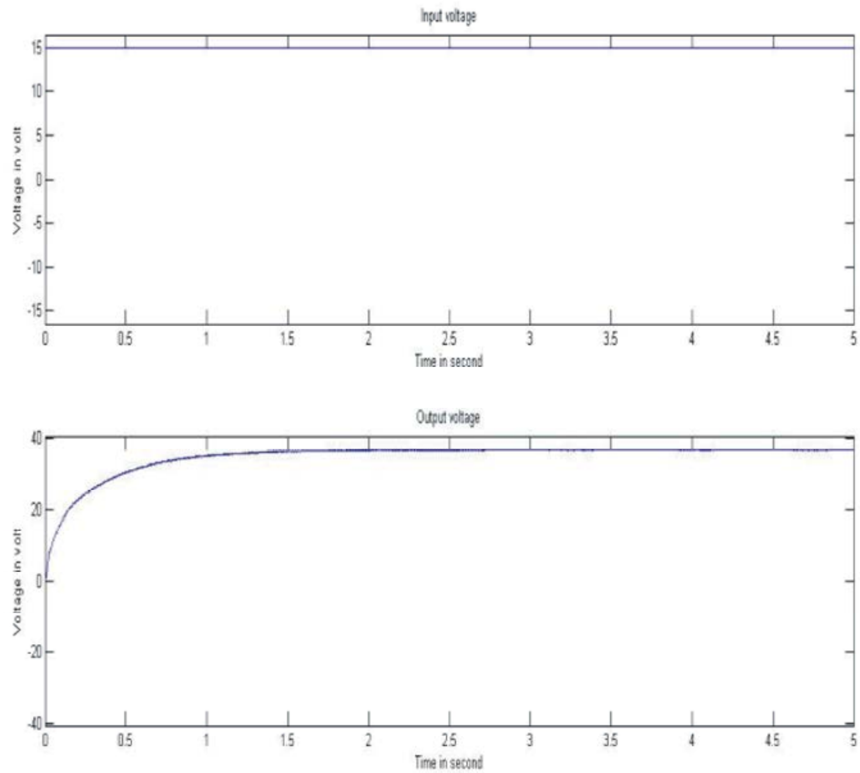

Fig. 5.3: Simulation results with PI Controller

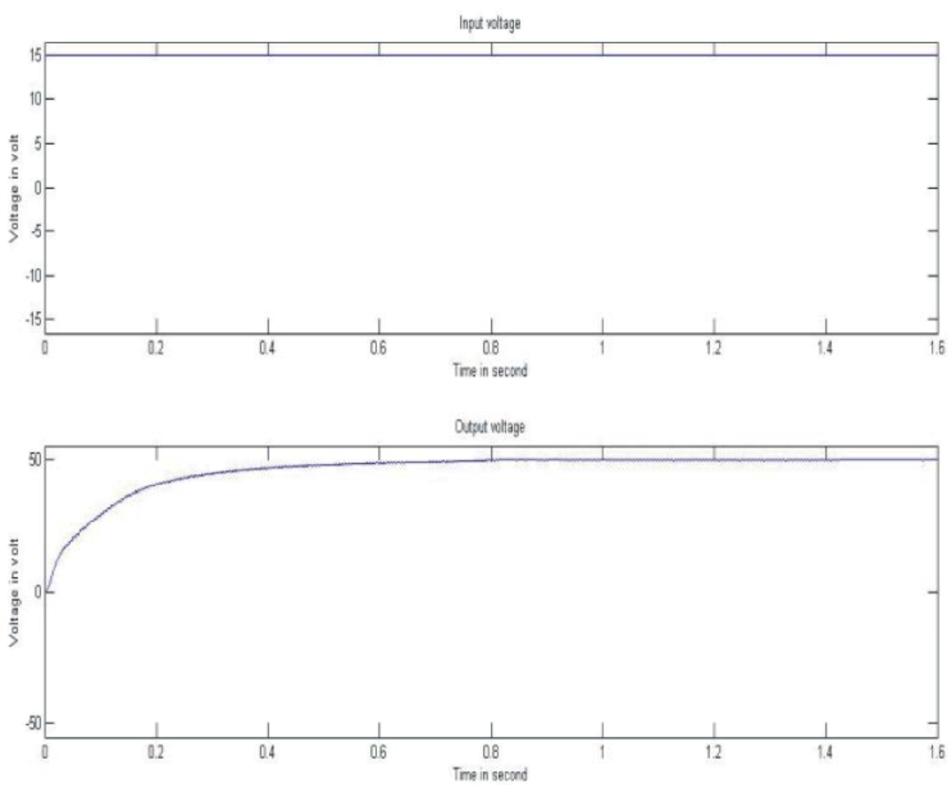

Fig. 5.4: Simulation results with Fuzzy Controller

Table 1: Performance Analysis

Characteristics	PWM Controller	PI Controller	Fuzzy logic Controller
Rise Time	3.0515	0.6867	0.2891
Settling Time	28.1280	1.4525	0.6821
Settling Min	4.5000	32.9359	44.6404
Settling Max	5	36.8345	50.1552
Overshoot	0	0.1926	0.5714
Undershoot	0	0.0272	0.0200
Peak	5	36.8345	50.1552
Peak Time	28.3034	4.9727	1.4447

CONCLUSION

For better performance of the SEPIC converter, several controlling techniques are used. In this paper, PI controller and fuzzy controller are used. For obtaining the steady response of the converter, PI controller is used and this response is mainly depends on the For better performance of the SEPIC converter, several controlling techniques are used. In this paper, PI controller and fuzzy controller are used. For obtaining the steady response of the converter, PI controller is used and this response is mainly depends on the frequency response of the boost converter. The design of fuzzy controller depends on the expert knowledge of the SEPIC converter and it is tuned using trial and error method. We apply two different models of the fuzzy controller i.e. one is to get faster response and the other is to reduce the steady state error. After implementing the design and parameters in the SEPIC converter, the results of the both PI controller and fuzzy controller are compared. For designing the PI controller, it has different procedures but it doesn't require particular mathematical model. Fuzzy controllers requires more tuning than PI controller because for designing, it demands more computation power.

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