



DESIGN AND ANALYSIS OF CONTROLLER INMODIFIED SEPIC DC-DC CONVERTER

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ABSTRACT

A high step up DC-DC converter based on the modified SEPIC converter is presented in this paper. The proposed topology Presents low ripple factor, low switch voltage and high efficiency for low input voltage. The magnetic coupling allows to increase the static gain with reduced switch voltage. Input voltage equal to 12V and efficiency equal to 93% was obtained with magnetic coupling with an output voltage equal to 210V and with feedback efficiency is 96% with an output voltage equal to 290V.

Index Terms- DC-DC power conversion, Zero current switching(ZCS), PI controller

I. INTRODUCTION

In general various DC-DC converter topologies have been used in the energy system. Irrespective of their differences. There are 5 main types of DC-DC converters. Buck converters can only reduce voltage, boost converters can only increase voltage, and buck-boost, Cuk, and SEPIC converters can increase or decrease the voltage. They all try to input the maximum amount of power from the system with as little loss of energy as possible within the circuit itself. DC-DC converter is a switching converter which inherently introduces certain amount of ripple which is minimized by using a filter at the output terminals. While this is a solution, the magnitude, cost and life of the filter dependent on the type of converters are used shown in Figure 1.

DC-DC converters are power electronic circuits commonly used as an interface between the voltage source and the load served. The development of high static gain DC-DC converters is an important research area due to the crescent demand of this technology for several applications. Normally single-switch three-diode dc-dc Pulse Width Modulated (PWM) converters operating at constant frequency and constant duty cycle.

Other advantages of the converters include lower voltage stress on the semiconductor devices, simple structure, and control [4].

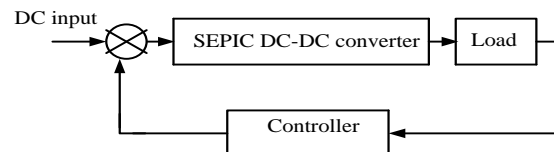


Figure 1 Block diagram of SEPIC converter However, the classical non isolated DC-DC converters present a limited step-up static gain ($q = V_o/V_i$). The boost converter is the classical non isolated step-up DC-DC converter and normally can operate with an adequate static and dynamic performance with a duty cycle close to $D = 0.8$ resulting in an output voltage around five times the input voltage. A DC-DC converter operating with a static gain range until $q = 5$ is considered a standard static gain, a static gain range higher than $q = 10$ is considered a high static gain solution and an operation with static gain higher than $q = 20$ is considered a very high static gain solution. The main desired characteristics in the considered applications are a static gain equal or higher than ten times, low switch voltage, low input current ripple, reduced weight and

volume, and high efficiency. New single-switch non isolated DC–DC converter with high voltage transfer gain and reduced semiconductor voltage stress hybrid switched-capacitor technique for providing a high voltage gain without an extreme switch duty cycle [1]. A comparison of the efficiency obtained from prototypes of both converters confirmed that the new ZCS converter is more efficient than the standard active-clamp ZVS converter for certain specific operating conditions[3].

II. OPERATION AND PRINCIPLE PROPOSED CONVERTER

The operation of the SEPIC DC-DC converter with magnetic coupling and output diode clamping presents five operation stages.

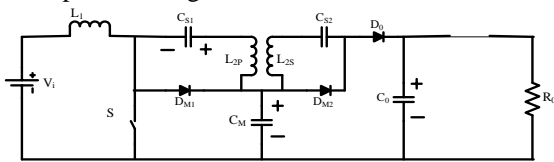


Figure 2 SEPIC converter with magnetic coupling

1) First stage: The power switch S is conducting and the input inductor L_1 stores energy. The capacitor C_{S2} is charged by the secondary winding L_{S2} and diode D_{M2} . The leakage inductance limits the current and the energy transference occurs in a resonant way. The output diode is blocked, and the maximum diode voltage is equal to $(V_o - V_{CM})$.

2) Second Stag: From the instant t_1 , when the diode D_{M2} is blocked, to the instant t_2 when the power switch is turned OFF, the inductors L_1 and L_2 store energy and the currents linearly increase.

3) Third Stage: At the instant t_2 the power switch S is turned OFF. The energy stored in the L_1 inductor is transferred to the C_M capacitor. Also, there is the energy transference to the output through the capacitors C_{S1} , C_{S2} inductor L_2 and output diode D_o .

4) Fourth Stage: At the instant t_3 , the energy transference to the capacitor C_M is finished and the diode D_{M1} is blocked. The energy transference to the output is maintained until the instant t_4 , when the power switch is turned ON.

5) Fifth Stage: When the power switch is turned ON at the instant t_4 , the current at the output diode D_o linearly decreases and the di/dt which is limited by the transformer leakage inductance, reducing the diode reverse recovery current problems. When the output diode is blocked, the converter returns to the first operation stage.

The static gain of the modified SEPIC converter with magnetic coupling and voltage multiplier are calculated by (1). The static gain can be increased by the windings turns ratio (n) without increasing the switch voltage

$$\frac{V_0}{V_i} = \frac{1}{1-D} \cdot (1+n) \quad (1)$$

where the inductor windings turns ratio (n) is calculated by

$$n = \frac{N_{L2S}}{N_{L2P}} \quad (2)$$

III. DESIGN OF PI CONTROLLER

Using Ziegler-Nichols first method

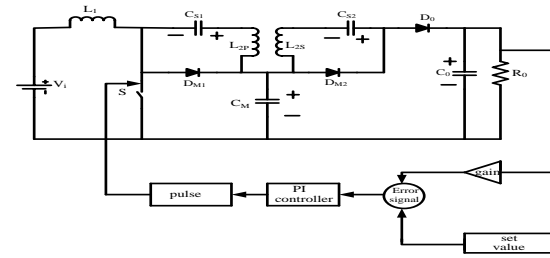


Figure 3 SEPIC converter with PI controller

The first method is applied to plants with step responses of the form displayed in Figure 5. This type of response is typical of a first order system with transportation delay, such as that induced by fluid flow from a tank along a pipe line. It is also typical of a plant made up of a series of first order systems. The response is characterized by two parameters, L the delay time and T the time constant. These are found by drawing a tangent to the step response at its point of inflection and noting its intersections with the time axis and the steady state value.

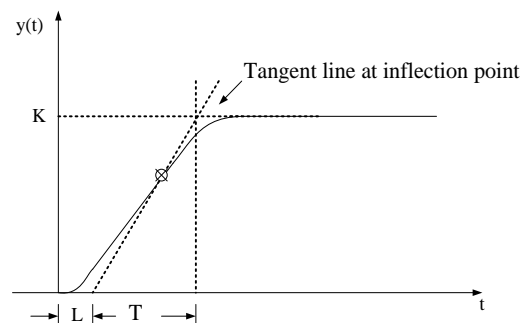


Figure 4 Response Curve for Ziegler-Nichols First Method

$$K_p = 0.9 \frac{T}{L} \quad (3)$$

$$T_i = \frac{K_p}{K_i} \quad (4)$$

Proportional and integral controllers are widely used in industrial control system because of reduced number of parameters to be tuned.

$$u(t) = K_p [e(t) + 1/T_i \int_0^t e(t) dt] \quad (5)$$

$u(t)$ and $e(t)$ denotes control and error signal and K_p, T_i are the parameters to be tuned. The corresponding transfer function in below,

$$K(S) = K_p (1 + 1/ST_i) \quad (6)$$

(or) equivalently,

$$K(S) = K_p [\frac{s + 1/T_i}{s}] \quad (7)$$

$$K(S) = K_p [\frac{s + Z}{s}] \quad (8)$$

Where, $Z = 1/T_i$

IV SIMULATION RESULTS

Simulation result is shown in above Figure in open loop analysis. Variation of input has to comparing the efficiency and output voltage shown in Table I. In Table III shows the buck and boost output voltage. In Figure 13 shows that waveform of buck mode voltage

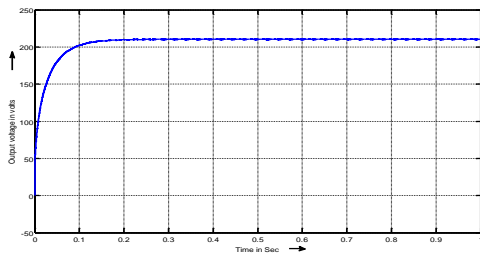


Figure 5 Output voltage- 210V(Input-12V)

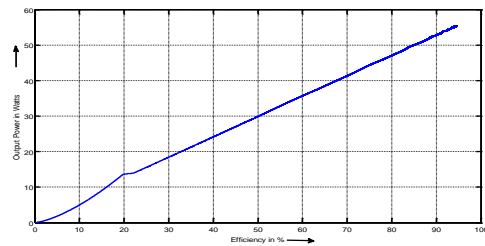


Figure 6 Efficiency-94% (Input-12V)

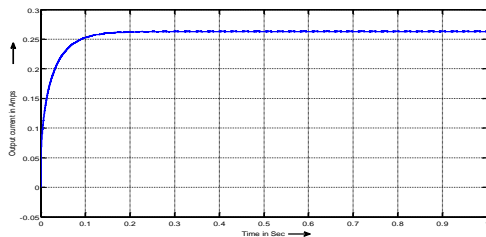


Figure 7 Output current-0.37A(Input-12V)

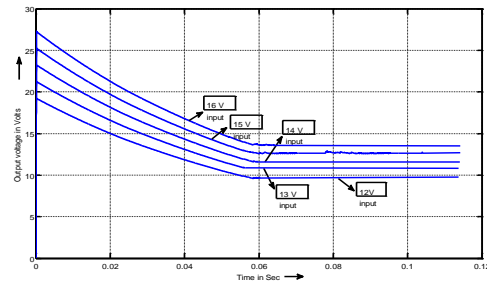


Figure 8 Buck mode output voltage

TABLE I

Variation of Efficiency with output voltage

Input Voltage (V)	Output Voltage (V)	Input Power (W)	Output Power (W)	Ripple Factor (%)
12	210	58.52	55.32	0.0806
13	228	68.8	64.98	0.067
14	245	79.62	75.44	0.0873
15	263	91.73	86.71	0.0859
16	281	104	99	0.0893

TABLE II

Improving efficiency using PI controller

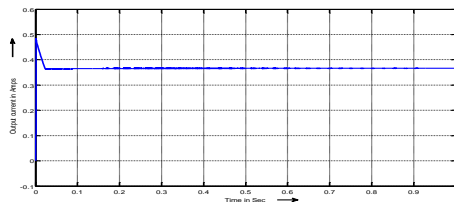
Input Voltage (V)	Efficiency (%)	Output Voltage (V)	Input Power (W)	Output Power (W)
12	96.6	290.7	110.4	106.6
13	96.3	291.5	110.8	106.2
14	96.12	292	110.9	106.6
15	95.8	292.3	111.4	106.8
16	95.5	293	113	108

TABLE III

Different modes are analyzed in DC-DC SEPIC converter

Input Voltage (V)	Buck Mode Output Voltage(V)	Boost mode Output Voltage(V)
12	10	210
13	12.2	228
14	12.6	245
15	12.86	263
16	14.43	280

Figure 9 Output voltage-290V (PI controller).



The output voltage and current signals of the proposed PI controller is shown in above Figure. The simulation The PI controller is selected for the comparison because of its severe use in industry application. The PI controller is designed well where it is optimized to produce minimum error signal. Furthermore, the output lies on the maximum voltage curve. The reason behind this that the PI controller address two main issues; the steady state error and maximum overshoot. If one need focus on time, the derivative controller must be added to become PID controller, but this cause instability in steady state.

VI CONCLUSION

The SEPIC DC-DC converter in open loop operation with resistive load performance is analyzed. In this paper to perform the SEPIC DC-DC converter with PI controller performance. It is operated with the efficiency of 96% and switching frequency of 24 kHz. The simulation results are presented. The closed loop system is performed over open loop system for maintaining the operating conditions at desired value.

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