International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 06, June 2017
ISSN: 2455-3778
http://www.ijmtst.com

# Dynamic Performance Investigation of Transformer less High Gain Converter with PI Controller

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**To Cite this Article**
Kommesetti R Venkata Durga Rao, B.Jaya Raju and S.Govinda Raju, "Dynamic Performance Investigation of Transformer less High Gain Converter with PI Controller", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 06, June 2017, pp. 54-58.

## ABSTRACT

*A new transformer less buck-boost converter with simple structure is proposed in thisstudy. Compared with the traditional buck-boost converter, the proposed buck-boost converter's voltage gain is squared times of the former's and its output voltage polarity is positive.*

*These advantages enable it to work in a wider range of positive output. The two power switches of the proposed buck-boost converter operate synchronously .In the continuous conduction mode (CCM), two inductors are magnetized and two capacitors are discharged during the switch-on period, while two inductors are demagnetized and two capacitors are charged during the switch-off period.*

*The operating principles, the steady-state analyses, and the small-signal model for the proposed buck-boost converter operating in CCM are presented in detail. The PSIM simulations and the circuit experiments are provided to validate the effectiveness of the proposed buck-boost converter.*



## I. INTRODUCTION

DC-DC converters are used to convert unregulated dc voltage to regulated or variable dc voltage at the output. The DC-DC converter is an electrical circuit that transfers energy from a DC voltage source to a load. The energy is first transferred via electronic switches to energy storage devices and then subsequently switched from storage into the load. The switches are transistors and diodes; the storage devices are inductors and capacitors. This process of energy transfer results in an output voltage that is related to the input voltage by the duty ratios of the switches. In they have many applications such as high intensity discharge lamp ballasts for automobile Headlamps, fuel-cell energy conversion systems, solar-cell energy conversion systems, and battery backup systems for uninterruptible power supplies requires DC–DC converte rwith a high step-up voltage gain. Theoretically, a high step- up voltage gain with an extremely high duty ratio can be achieved by DC–DC boost converter[1]–[3]. How ever, in practice power switches, rectifier diodes, and the equivalent series resistance ofinductors and capacitors limit step-up voltage gain to limited values. A serious reverserecoveryproblem is due to the extremely high duty-ratio in dc-dc boost converter. To overcome this recovery problem so many topologies have been introduced and to provided high step-up voltage gain without extremely high duty-ratio .

A simple structure with a high step-up voltage gain and an electrical isolation is dc-dc fly back converter but active switch in this converter suffers with high voltage stress due to the leakage inductance of the transformer. To minimize the voltage stress and to recycle the energy of the leakage inductance, few energy regeneration techniques are introduced[4]-[6].In these techniques, coupled-inductor technique can provide high voltage gain with a low voltage stress on the active switch of converters, and high efficiency without the problem of high duty ratio ratio.

In the past research on the transformer less dc-dc converters are happened, these include cascade boost type[16],the quadratic boost type[17],the voltage-lift type[18]– [20],the capacitor-diode voltage multiplier type[21],[22],and the boost type integrating with switched-capacitor technique[23].These techniques are all complex and are having high cost. The modified boost type with switched inductor technique is shown in Fig.1 [24]. It has very simple structure because only one power stage is used in this converter.

However, this converter has two issues:

(1) During the switch-on period, three power devices exist in the current-flow path and during the switch-off period, two power devices exist in the current-flow path and (2) The output voltage is equal to the voltage stress on the active switch.

A transformer less dc–dc high step-up converter is propose in this thesis, as shown in Fig1.2, compared with the convert in [24], the proposed converter has the following merits:

1) During the switch-on period two power devices exist in the current flow path and during the switch-off period, one power device exist in the current flow path.

2) The voltage stresses on the active switches are less than the output voltage; and 3) Under the same operating conditions, including input voltage, output voltage, and output power, the current stress on the active switch during the switch-on period is equal to the half of the current stress on the active switch of the converter in

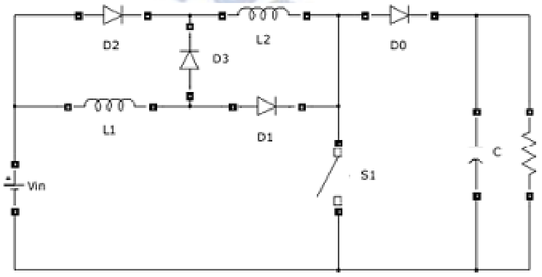



*Figure 1.1 Transformer less dc–dc high step-up converter*

These proposed dc–dc converter utilizes switched-inductor technique, in which during the switch-on period two inductor switch same level of inductance are charged in parallel and during the switch-off period these are discharged in series, to achieve high step-up voltage gain without the extremely high duty ratio. The operating principles and steady-state analysis are discussed in the following sections. Some conditions are assumed to analyze the steady- state characteristics of the proposed converters and these are as follows:

1) All components are ideal and the ON-state resistance RDS (ON) of the active switches, the forward voltage drop of the diodes, and the equivalent series resistance (ESR) of the inductors and capacitors all are ignored.

2) All Capacitors are sufficiently large and voltages across the capacitors can be treated as constant.

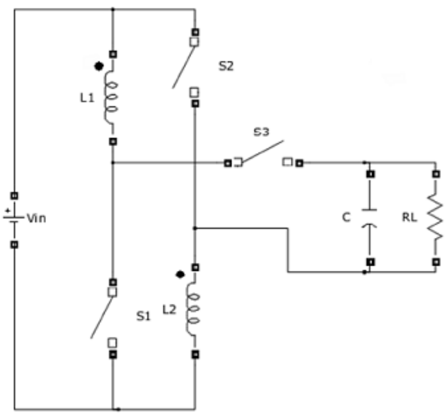



*Figure 1.2 Proposed high step up dc-dc converter*

Fig.1.2 shows the circuit configuration of the proposed converter, consisting of two active switches (S1 and S2) two inductors (L1 and L2) with the same level of inductance, one output diode Do and one output capacitor Co. Switches S1 and S2 are controlled simultaneously with one control signal. The operating principle and steady- state analysis of Continuous conduction Mode (CCM) are presented in detail as follows.

## II. OVERVIEW OF CONTROL

Most DC–DC converters are designed with a closed-loop feedback controller to deliver a regulated output voltage. The main objective is to ensure that the converter operates with a small steady-state output error, fast dynamical response, low overshoot, and low noise susceptibility, while maintaining high efficiency and low noise emission.

All these design criteria can be achieved through the proper selection of control strategies, circuit parameters, and components. Before moving on to the discussion on control methodologies, it is important to understand the various factors that affect the control performance.

***Factors Influencing Control Performances***

This section discusses how the switching frequency, the energy storage elements of the converter, the gain parameters, and the type of the controller would affect the control performance of a converter.

***Switching Frequency***

Theoretically, ideal control is achievable only if the switching frequency is infinitely high. The term ideal control, in our context, would mean perfect DC steady state regulation (i.e., zero error and noise susceptibility), infinitely fast dynamic response, and no overshoot.

However, since all practical systems are subjected to time delay and slew rate limitation of circuit components, an infinitely high switching frequency operation is unattainable.

The magnitude of the switching frequency is therefore limited by the bandwidths of the circuit components, i.e., the controller, power switch, diode, etc. Moreover, i t is also well known that the amount of power loss in a converter increases as the switching frequency increases. This is true even if soft-switching techniques are applied to reduce the switching losses of the power switches and/or diodes. It should be noted that eddy current and hysteresis current losses of the magnetic components and ac resistive power losses of the circuit due to skin effect will increase as switching frequency increases. Of course, all these losses may be relatively lower than the losses generated by the switches.

Nevertheless, it should be considered when determining the switching frequency of a converter since they will become significant when the frequency is very high. Furthermore, the emission of high-frequency noise may cause undesirable radio and electromagnetic interferences. All these factors will limit the practicality of very fast switching frequency to achieve an ideal regulation.

Fortunately, in most applications, an ideal power converter is often not needed. What is actually required is a power converter that meets some line/load regulation criteria, ac ripple criteria, dynamic response criteria, and size, weight, and efficiency criteria. Therefore, the selection of the switching frequency should always be a tradeoff between achieving the desired control performance to meet consumer specifications and minimizing power losses, power density, and electromagnetic interference. Nevertheless, it is true that the control performance of a converter can always be improved with a higher switching frequency.

## III. ENERGY STORAGE ELEMENTS

The size of the inductive and capacitive energy storage elements, i.e., L and C can also affect the control performance of a DC–DC converter. This can be understood by examining the operating mechanism of these elements. Since the rate of storing/ releasing electrical energy, i.e., $\tau$ = rL C (capacitor) and $\tau$ =L/rL (inductor), is directly affected by the size of the energy storage elements, the ability to respond to the load changes is therefore also affected by the size of the energy storages.

Specifically, for a fixedfrequency operation, the dynamic response of the converter will generally be faster with a smaller value of L or C , since a smaller energy storage element requires a shorter time to store and release energy. On the other hand, a smaller value of L will lead to a higherripple inductor current and a smaller output voltage undershoot or overshoot during a step increment or step decrement in the load current.

Yet, a larger value of C will give a smaller output voltage undershoot during a step increment in the load current, and a smaller output voltage overshoot during a step decrement in the load current.

Thus, the size of the storage elements together with the control design determine the dynamical behavior of the controlled converter. In fact, there have been some proposals about using a variable inductor to alter the dynamical response of power converters.

## IV. COMMON CONTROL TECHNIQUES

This section presents the various techniques used in the control of DC–DC converters, as well as the approaches for designing the controllers.

***Hysteretic Controllers***

Prior to the introduction of fixed-frequency pulse-width modulation (PWM) integrated-circuits (IC) controllers, the most commonly used control technique was perhaps the hysteretic controller

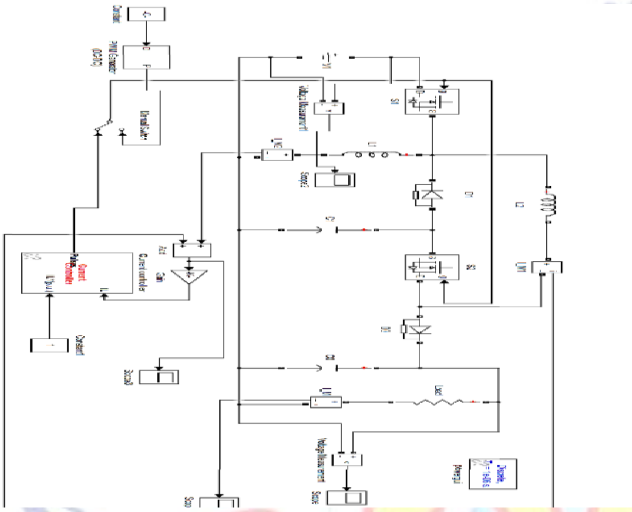
## V. SIMULATION CIRCUITS & RESULTS

***Model Simulation and Results***

MATLAB based Schematic of A New Transformer less Buck-Boost Converter With Positive Output

Voltage is shown in Fig. 5.1. The model iscontrolled with the help of a pulse width modulation with proper time intervals.

All the switches that were used are modeled with the help of IGBT switches.Current Mode Controller is shown in Fig 5.2. Current through Inductor is inFig.5.3, Current through load is in Fig.5.4, The load voltage is shown inFig 5.5, Voltage across Source is shown in Fig.5.6.



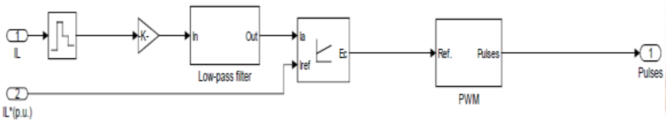



***Figure 5.2 Current Mode Controller***

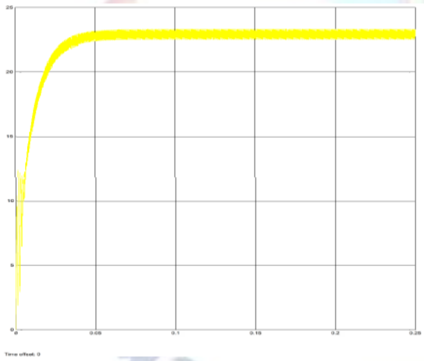


*FIG.Inductor Current*

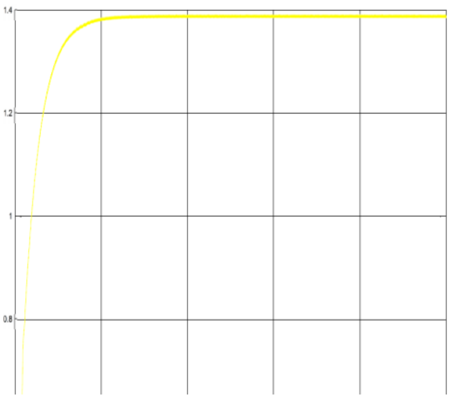


*FIG-Load Current*

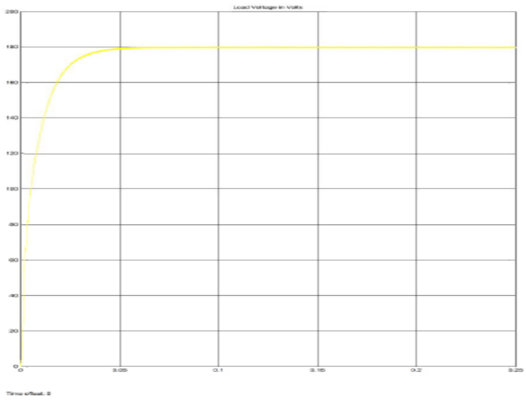


**Figure 5.5 Load Voltage**

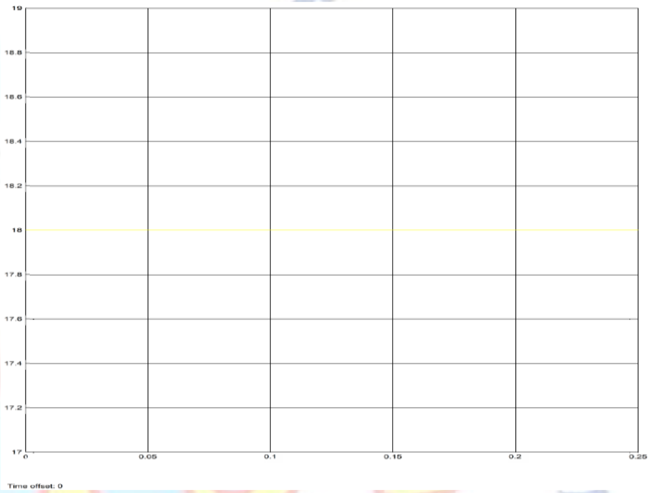


*Fig- Source Voltage*

## VI. Conclusion

A new PI based current mode PWM control is designed for Transformer-less high gain buck-boost converter to operate the converter in boost mode. The PI controller maintains the load voltage within the specified limits over a wide range of duty ratios and the converter achieves high conversion gains at reasonably good duty ratios, for the maximum duty ratio that considered in the analysis is 0.756 for which the conversion gain is equal to 10. The PI control scheme has the ability of providing a tight control to maintain load regulation within the limits. From the simulation studies this converter configuration is suitable for the industrial applications requiring high conversion gains especially for boost operation.

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