CONTROLLER DESIGN OF BOOST CONVERTER

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NOVEMBER 2005

I admitted that I have read this report and my opinion this report are fulfillment the scope and quality for the Degree Of Bachelor In Electrical (Industry Power) graduation.

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"I admitted that this project is written by me and is my own effort and that no part has been plagiarized without citation."

Signature :...

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Date : 21 NOVEMBER 2005

For my loved father and mother
Mohd Aripin B. Hj Agam and Hasnah Bt. Ahmad
In appreciation of supported and understanding.

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First and foremost, I would like to thank the Almighty God for letting me this chance of completing the project up to this point in time.

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ABSTRACT

In this project, a techniques of averaging and linearization is used for designing the controller of boost converter. From this techniques that applied to the boost converter we can obtain a simple converter's transfer function, which is may then be used for converter's controller design. The proposed controller should provide a good line and load regulation toward the converter's closed loop circuit. The modeling and simulation of the boost converter is execute by using software application (simulink MATLAB and ORCAD).Modeling, design and analysis process is made to develop and produce a good line and load regulation.

ABSTRAK

Di dalam projek ini teknik pemurataan dan juga penglinearan digunakan untuk merekabentuk pengawal bagi penukar boost ini. Daripada teknik ini yang telah di aplikasikan kepada penukar boost, ia mampu menghasilkan sebuah rangkap pindah penukar yang mana ia akan digunakan ke dalam rekaan pengawal penukar boost. Tujuan utama pengawal ini di bangunkan adalah untuk menghasilkan satu pengaturan talian dan juga pengaturan beban merujuk kepada litar penukar gelung tertutup. Permodelan dan simulasi terhadap penukar boost adalah dilaksanakan dengan menggunakan applikasi perisian dari simulink MATLAB dan ORCAD. Secara keseluruhan permodelan, rekaan dan analisis dijalankan adalah untuk dapat menbangunkan sebuah penukar yang yang memiliki pengaturan talian dan pengaturan beban.

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CHAPTER 1

INTRODUCTION

BOOST CONVERTER

Boost converter or step-up converter, is switching DC/DC converter that produces an output voltage greater than the source in higher average output voltage. Boost converter is consisting a prime component that will build in the converter as diode, inductor, capacitor, power Mosfet and PWM controller. That will including the simulation, analysis, design and testing by follow the term and specification[1].

In many application, it is required to convert a fixed voltage dc source into a variable voltage dc source. A boost converter converts directly from dc to dc and is simply known as a dc converter. A controller design of boost converter can be considered as dc equivalent to an ac transformer with a continuously variable turns ratio. Like a transformer it can be used to step up a dc voltage source.

Boost converter are widely used for traction motor control in electric automobiles, trolley cars, marine hoists, forklift truck and mine haulers. They provide smooth acceleration control, high efficiency, and fast dynamic response. The boost converter can be used in regenerative braking of dc motor to turn energy back into the supply and this feature result in energy saving for transportation system with frequent stops[1].

1.1 Objective

The objectives of this project are :

a. To study on the design methodology of closed loop boost converter in order to get an expected result.
b. To design a controller such that the converter have a good line and load regulation in controller design of boost converter.
c. To determine a transfer function of the converter using averaging and linearization technique.
d. To verify that the design controller could produce the expected result by following the characteristic of controller.
e. To study how to solve a problem by referring a problem statement and try to use a good simulator in any simulation to get a good result.

1.2 Project Scope

In this project the focusing is produce a controller of boost converter where the controller should provide a good line and line regulation toward the converter's closed loop circuit. The modeling is created to the controller where the purpose is to make a one modeling that follow the criteria of controller of boost converter. Firstly inside the boost converter circuit with averaging techniques will produce a averaged converter circuit. Than from the signal through the small signal linearization that will produce a small signal averaged circuit. From here the circuit will analyze refer to produce a transfer function from the boost converter. Here analyze on boost converter transfer function will consist of loop gain, phase gain and gain margin. The value from the analyze will ensure that what the modeling of compensator before the simulation is implemented to find the good line and a good load regulation.

1.3 Project Methodology

The methodology on this project is to describe the procedure and methods to be used to archive the project objectives of the proposed project. Firstly the purpose of project methodology is to make a revision, review and study about the controller of boost converter. Then one of designing of boost converter is determined to find the parameter by follow the averaging techniques and linearization that will be produce a transfer function and it will be supported with simulating the controller design by using MATLAB and ORCAD. From the design of the controller for boost converter it should provide a good load and good line regulation.

1.4 Modeling and Controller

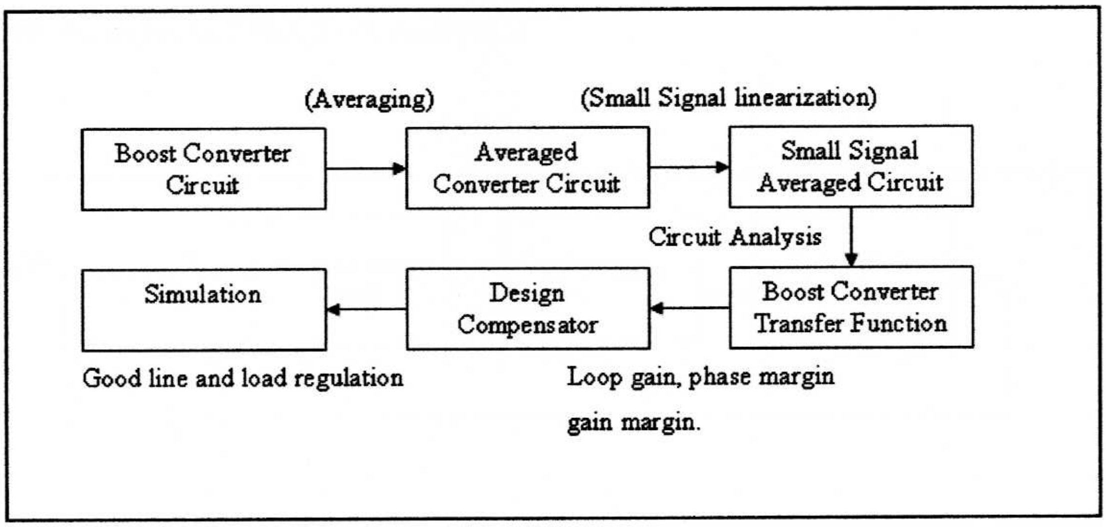

Figure 1.1 : Modeling and Controller

CHAPTER 2

PROJECT BACKGROUND

In this chapter the explanation and implementation about design controller of boost converter how it is designed. The closed loop of boost converter is basically divided to 3 sections there are boost converter circuit, compensator and pulse width modulator controller (PWM). The project is build refer to the project design, conception, specification and any information that is related to improve the project. In a controller of boost converter is divided to 3 main block diagram that will ensure that the expected result to be archived :

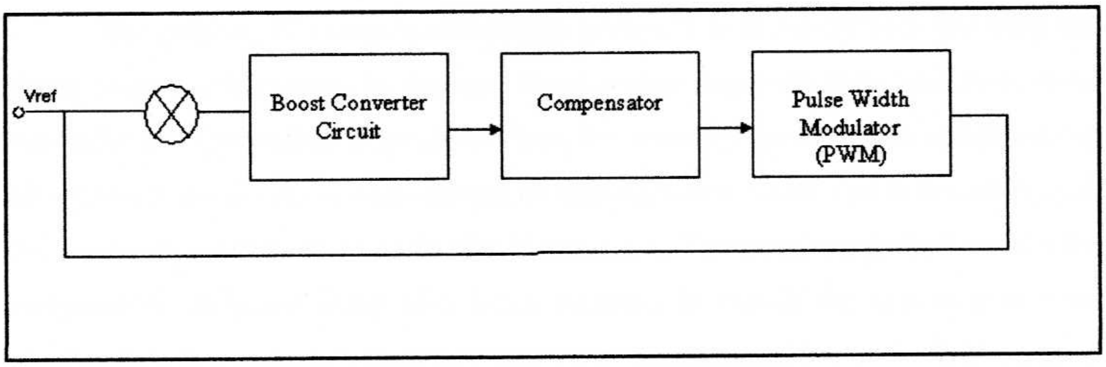

Figure 2.1 : Controller Of Boost Converter Block Diagram

2.1 Boost Converter

Boost converter or step-up converter, is switching DC/DC converter that produces an output voltage greater than the source in higher average output voltage. Boost converter is consisting a prime component that will build in the converter as diode, inductor, capacitor, power Mosfet and PWM controller.

A boost converter can step up the output voltage without transformer, due to a single transistor it has a high efficiency. The input current is continuous however a high-peak current has to flow through the power transistor. The output voltage is very sensitive to changes in duty cycle k and it might be difficult to stabilize the converter. The average output current is less than the average inductor current by a factor of (1- k), and much higher rms current would flow through the capacitor[2].

2.2 Compensator

The purpose of compensator design generally is to satisfy both transient and steady-state specifications. In the root locus design approach presented here, these two tasks are approached separately. First, the transient performance specifications are satisfied, using one or more stages of compensation. Once that is accomplished, the steady-state error can be dealt with if necessary. The terminology that use for the compensator designed using root locus methods to satisfy the steady-state error specification in standard of three pole two zero compensator. It will always be a good compensator, and it is has the mission of reducing steady-state error without having any effect on the transient performance compensation that has already been done. Therefore, this special compensator is not supposed to reshape the root locus as would be done to satisfy transient performance specifications[3].

2.3 Pulse Width Modulator (PWM)

Pulse width modulator (PWM) are known as inverter where the function of an controller is to change a dc input voltage to a symmetric ac output voltage of desired magnitude and frequency. The output voltage could be fixed or variable at a fixed or variable frequency. A variable output voltage can be obtain by varying the input dc voltage and maintaining the gain of the converter constant[4]. If the dc input voltage is fixed and it is not controllable, a variable output voltage can be obtained by varying the gain of the controller, which is normally accomplished by pulse width modulation (PWM) within the controller. The controller gain may be define as the ratio of the ac output voltage to dc input voltage.

The output voltage waveform of ideal inverters should be sinusoidal. However the waveform of practical controller are nonsinusoidal and contain certain harmonics. For low and medium power application, square wave or quasi square wave voltage may be acceptable and for high power application, low distorted sinusoidal waveform are required. With the availability of high speed power semiconductor devices, the harmonic contents of output voltage can be minimized or reduced significantly by switching techniques[1].

CHAPTER 3

LITERATURE REVIEW

This chapter review existing project created to get an idea about the project design controller of boost converter by following conception, specification and any information that related to improve the project. In later of this chapter, some review about design controller of boost converter that proposed to fulfill this project will be reported.

3.1 Analysis Of Boost Converter

The boost converter, or step-up converter, is switching DC/DC converter that produces an output voltage greater than the source.

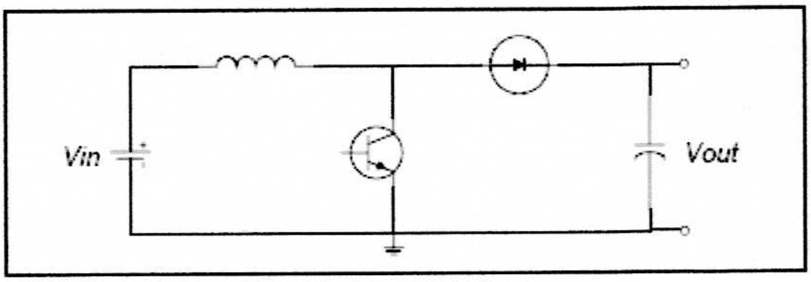

Figure 3.1 : The Boost Converter

A basic boost configuration is depicted in Figure 3.1. Assuming that the switch (the transistor) has been open for a long time, and the components are ideal, the voltage across the capacitor is equal to the input voltage[4].

3.2 Charge

Figure 3.2 shows the charge phase. When the switch closes, the input voltage is flowing across the inductor. The diode prevents the capacitor from discharging to ground. Because the input voltage is DC, current through the inductor rises linearly with time at a rate that is proportional to the input voltage divided by the inductance. The current through the inductor increases and the energy stored in the inductor builds up[5].

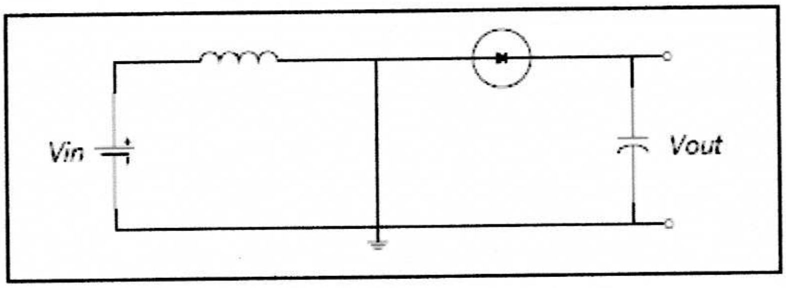

Figure 3.2 : Boost Converter Charge Phase

3.3 Discharge

Figure 3.3 shows the discharge phase. When the switch opens, the voltage across the inductor changes to whatever is required to maintain current flow. The inductor is discharging its energy and the polarity of inductor voltage is such that its terminal connected to the diode is positive with respect to its other terminal connected to the source. Now the capacitor voltage is higher than the source voltage. The inductor receives energy when the switch is closed and transfers it to the output when the switch is open. When the capacitor is relatively large, Vout remains relatively constant during the second half of the cycle[6].

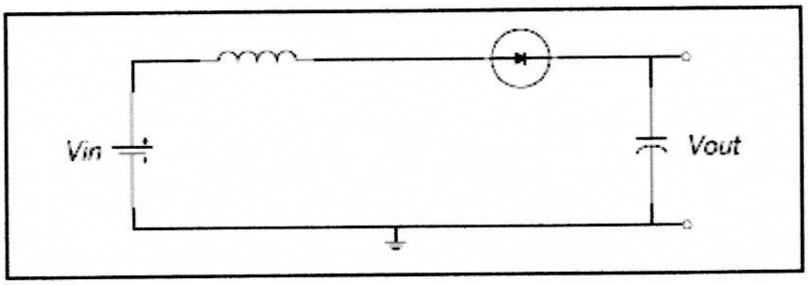

Figure 3.3 : Boost Converter Discharge Phase

If we continue this process over and over, the voltage across the capacitor (VOUT) will rise with every cycle.

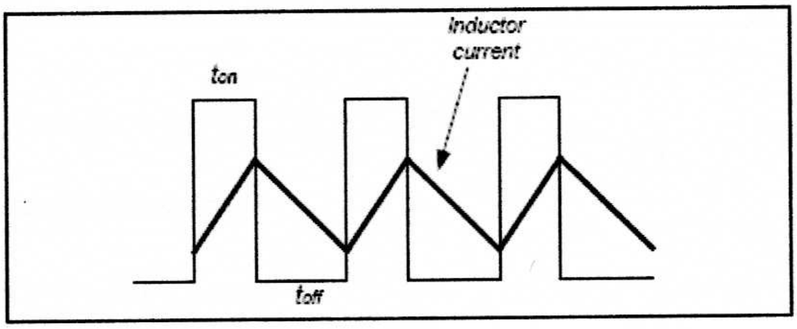

Figure 3.4 : Inductor Current

3.4 Inductor voltage and capacitor current waveforms

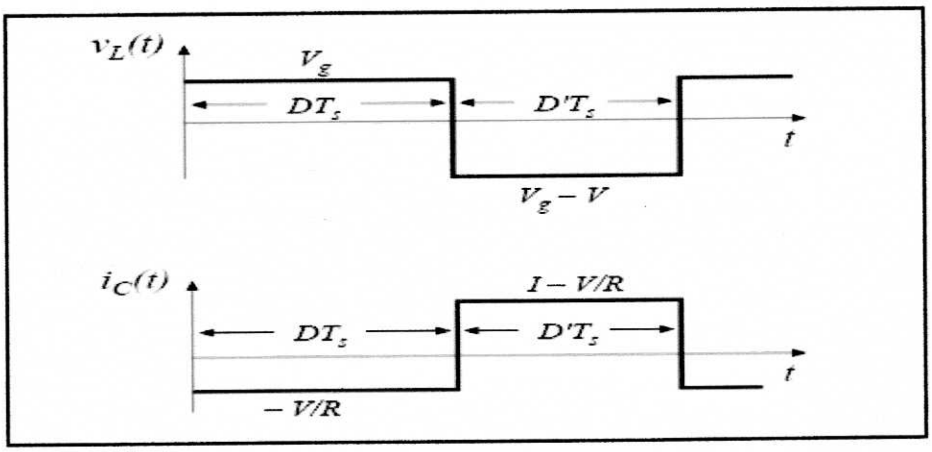

Figure 3.5 : Inductor voltage and capacitor current waveforms

3.5 Inductor volt-second balance

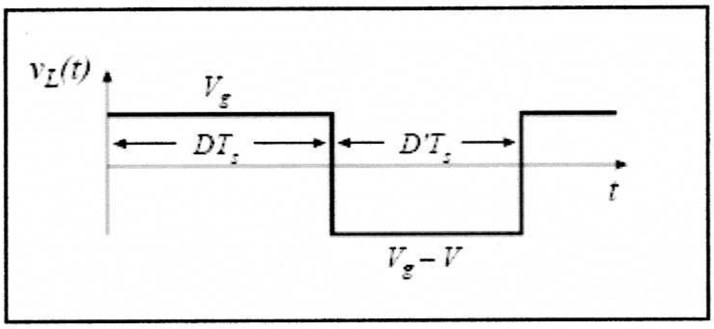

Figure 3.6 : Inductor volt-second balance

Net volt-seconds applied to inductor over one switching period :

$$\int_0^{T_s} v_L(t)\,dt = (V_g)\,DT_s + (V_g - V)\,D'T_s \tag{3.1}$$

Equate to zero and collect terms :

$$V_g\,(D + D') - V\,D' = 0 \tag{3.2}$$

Solve for V:

$$V = \frac{V_g}{D'} \tag{3.3}$$

The voltage conversion ratio is therefore

$$M(D) = \frac{V}{V_g} = \frac{1}{D'} = \frac{1}{1-D} \tag{3.5}$$

3.6 Determination of inductor current ripple

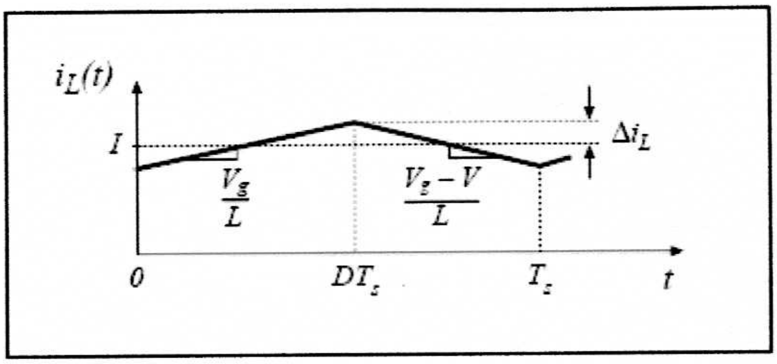

Figure 3.7 : inductor current ripple

Inductor current slope during subinterval 1 :

$$\frac{di_L(t)}{dt} = \frac{v_L(t)}{L} = \frac{V_g}{L} \tag{3.6}$$

Inductor current slope during subinterval 2 :

$$\frac{di_L(t)}{dt} = \frac{v_L(t)}{L} = \frac{V_g - V}{L} \tag{3.7}$$

Change in inductor current during subinterval 1 is (slope) (length of subinterval :

$$2\Delta i_L = \frac{V_g}{L} DT_s \tag{3.8}$$

Solve for peak ripple:

$$\Delta i_L = \frac{V_g}{2L} DT_s \tag{3.9}$$

Choose L such that desired ripple magnitude is obtained