A MODIFIED PID CONTROLLER FOR DC-DC BOOST CONVERTER

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A report submitted in partial fulfillment of the requirements for the degree of electrical engineering (Control, Instrumentation & Automation)

Faculty of Electrical Engineering

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2017
APPROVAL

I hereby declare that I have read through this report entitled “A MODIFIED PID CONTROLLER FOR DC-DC BOOST CONVERTER” and found that it has complied the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation & Automation).

Signature: .................................
Name: Dr. Azrita Binti Alias
Date: 19/6/2017
DECLARATION

I declare that this report entitles "A MODIFIED PID CONTROLLER FOR DC-DC BOOST CONVERTER" is the result of my own research except as cited in the reference. The report has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature: .......................................................... 
Name: AHMED ABBAS ALI
Date: 19/6/2017
DEDICATION

To my beloved Mother, Father, Family and Friends
ABSTRACT

Recently, the advancement in power electronic is increasingly growing. Power electronic circuit is a circuit that uses to converter the source energy from one form to another. The utilization of power electronic in nowadays application contributes significantly to produce well-functioning and less complex designed. DC-DC converters are an essential part of power electronic which focus on changing the DC voltage input level whether to higher or lower level. Boost converter is one of DC-DC converters, it's also known as a step-up output voltage. It can be applied to replace the transformer due to more flexible, able to produce a higher output voltage at high efficiency, as well as the building of boost converter is simple and easy to be analyzed, offered at a low price and less noise.

This project aims to design a DC-DC boost converter that will be driven with utilizing Pulse Width Modulation (PWM) where the DC level compared with carrier signal. In addition, Proportional-Integral-derivative (PID) controllers have usually been applied to the DC-DC boost converter due to its simplicity of design. However, this implementation of this control method cause suffers on the dynamic response of boost converter output voltage. Thus, the motive of this project is to modify this PID controller to improve its performance and generate the desired output voltage.
ABSTRAK

Kemajuan dalam kuasa elektronik semakin pesat berkembang. Litar kuasa elektronik adalah litar yang digunakan untuk menukar tenaga sumber dari satu bentuk ke bentuk yang lain. Penggunaan kuasa elektronik pada masa kini menyumbang kepada penggunaan sistem yg ringkas secara optimum. Penukar DC-DC adalah bahagian yang penting bagi kuasa elektronik yang memberi fokus kepada perubahan tahap input voltan DC sama ada tahap yang lebih tinggi atau lebih rendah. Pengubah boost adalah salah satu daripada penukar DC-DC, ia juga dikenali sebagai voltan langkah keluaran. Ia boleh digunakan untuk menggantikan pengubah kerana lebih fleksibel, mampu menghasilkan voltan yang lebih tinggi dan keluaran pada kecepatan tinggi, serta pembinaan rangsangan pengubah adalah mudah dan mudah untuk dianalisis, ditawarkan pada harga yang rendah dan kurang bertindak kepada ganguan luar.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

DC-DC converters are advice that converts an input voltage to lower or higher output voltage. It is a sort of electric power converter. DC-DC converters are used in traditional application such as solar photovoltaic (PVs) system, electric vehicle, DC motor drives, DC power supplies and telecommunication. DC-DC converters use to increase or decrease the output voltage from the lower input voltage. There is three general application of DC-DC converter, the converters are known as boost, buck, and buck-boost converters. Figures 1.1 and 1.2 show the diagram of PVs system and the configuration of DC-DC boost converter, respectively. The proposed of designing DC-DC Boost Converter is to maximize the unregulated DC voltage that is generated by the solar panel to a higher output voltage that required by batteries.

![Diagram of PVs system]

Figure 1.1: The diagram of PVs system
1.2 Motivation

This final year project is based on the title “Modified PID for dc-dc boost converter”. Boost converter is also known as a step-down converter where it produces an output voltage that is lower than the input voltage. Modified PID is being design based on the reference from the classical PID. The benefit of modified PID is it helps to ensure a better output response and a more desired output based on the requirement. This DC-DC boost converter is designed specially to boost low voltages. Therefore, it is useful in boosting low solar panel (12V) to higher voltage so that 36Vdc can be generated. At this time, the efficiency is also high and it is cost effective. It is also a transformerless topology. In order to achieve a stable output voltage at the output terminal, a modified PID is added into the design to produce a better output response for the system. This design helps the global by producing a high output voltage based on the demand for usage such as the solar panel by using this design is better than using a transformer which produces lots of heat and energy that will be loss to the surrounding and produces lots noise. This design is more convenient to be used in global and the cost of this design is affordable if compare to use of the transformer.
1.3 Problem Statement

A suitable design of DC-DC boost converter can step-up the voltage from its input supply to its output load. DC-DC converter contains of power semiconductor devices which are operated as electronic switches. The process of the switching devices causes the DC-DC boost converter to be nonlinear characteristic.

A conventional PID control system not able to produces a desired output voltage based on the requirement. Therefore, to improve the system, a modified PID is required instead of classical PID to produce a better output as desired and to enhance the system. DC-DC boost converter and the switching PWM are simulated using MATLAB.

1.4 Objectives

The objectives of this project are:

I. To design a PWM switching manner of DC-DC boost converter.
II. To propose a modified PID as a feedback control system to address issues of step-changes in reference and load for DC-DC boost converter.
III. To compare the system's responses between the conventional cascaded PID and the proposed modified PID controller.

1.5 Scope

The scopes of this project are list below:

i. Simulate the DC-DC boost converter that has a specification of $V_I = 12$ and $V_o = 36$.
ii. Apply a mathematical Model of DC-DC boost converter.
iii. Modeling and simulating the PWM switching manner of DC-DC boost converter.
iv. Simulate and design PID controller, and modified PID controller MATLAB/SIMULINK.
v. Compare the results of conventional PID and modified PID controllers.
1.6 Report outline

This report contains five chapters. The first chapter explains about introduction which includes the motivation, objectives, and scope of this project. Theory and literature review on DC-DC converters are discussed in chapter 2. In Chapter 3, the methodology of this project is described in detail. Chapter 4 consists of all results obtained. Lastly, Chapter 5 covers the conclusion of the project.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, the advancement in power electronic is increasingly growing. Numerous researchers have given a great effort in order to design and develop new and sophisticated power electronic devices that can be utilized in various applications. Power electronics circuits used to convert electric power from one source to another through converter devices. The circuit of power electronic function consist of a semiconductor as switches, so that, adjusting or operating monitoring a (voltage or current). Power electronics applications domains from high-powered tools, be it dc power transmission, cordless screwdrivers, power supplies for a variety of applications, laptop, hybrid automobiles, and mobile charger[1].

2.2 DC-DC Converter

A DC-DC converter is a circuit that utilized to converts an input DC voltage and generates an output DC voltage. Usually, the output generated is higher or lower compared to the input voltage. Furthermore, DC to DC converters is utilized to provide noise isolation. Figure 2.1 shows the symbol of DC-DC converter. There are three familiar types of DC to DC converter, be it buck, boost and buck-boost converter, they are utilized to step-up or step-down the output voltage [2].
2.2.1 DC-DC Buck Converter

step-down also known as a buck converter is power converter that usually utilized to reduce the output DC voltage to the desired value which will suit a corresponding application. the buck converter is a common non-isolated power stage topology. The buck converters can convert a voltage input 7volts into a lower adjusted output voltage classically to 0.4volts. the main component of Stepdown converters circuit is a diode, a switch, at least one inductor and capacitor. those basic components are able to transfer small packets of energy. Buck converters in most situations propose higher efficiency. The power switch connected in series with power supply, while the diode is connected in parallel. The buck converter can work in different methods; discontinuous and continuous mode. Figure 2.2 shows the circuit of buck converter [3].
2.2.2 DC-DC Boost Converter

Boost converter or voltage step-up converter is the converter that uses to step-up the voltage of DC supply to meet the required voltage demanded by selected application. Its powerful device which can easily increase 12V DC in Photovoltaic (input voltage source) to 30-36V required by the battery charger. The boost is a common non-isolated power stage topology, the main component of step-up converters circuit is a diode, a switch, at least one inductor and a capacitor, the basic construction of this components is quite simple, boost converter uses inductor and diode in series with DC supply while a power switch connected parallel. Figure 2.3 shows the diagram of boost converter [4].

![Figure 2.3: The block diagram of boost converter](image)

2.2.3 DC-DC Buck-Boost Converter

Step-up/down also known as a buck-boost converter is power converter that usually applied to step-up or step down the output voltage, it is a sort of DC to DC converters that combine two functions of boost and buck converters in one circuit. Figure 2.4 shows a block diagram of the buck-boost converter, the construction of buck-boost converter circuit is that the power switch (IGBT) connected in series with power supply voltage and the inductor connected in parallel, while the capacitor connected in parallel to the load. [5].
2.3 Pulse Width Modulation DC-DC Converters

Pulse Width Modulation (PWM) is a technique which converts an analog signal into digital signal. Pulse Width Modulation (PWM) signals have been widely employed in power electronic applications, there are many uses for PWM include Telecommunications, DC motors, RC devices, Audio/video effects, Voltage regulation and LED (increase and decrease the brightness). The idea of high (1) and low (0) that PWM signally produces is the remarkable approach of controlling semiconductors switches. DC-DC converters are power converter which converts a DC sources from one voltage level to another level (higher or lesser) simply by changing the duty cycle of the power switching in the converter circuit [6]. Figure 2.5 shows Pulse Width Modulation (PWM) generation.

A duty cycle can be expressed as the percentage of one period in which a signal is active. A period is a time it takes for the signal to complete an ON and OFF cycle. A duty cycle expressed as:

$$D = \frac{T}{P} \times 100\%$$
2.4 Feedback controller

Feedback controller can be defined as a target assigned to one or several state-variable such is output. A circuitry monitors the output voltage deviations with respect to the input voltage and output currents. If the output voltage deviates from its target, an error is created and fed-back to the power stage for action. The action is a change in the control variable: duty cycle (VM), peak current (CM) or the switching frequency. Such a control system is necessary if it is desired to change the output voltage set point, or if the system conditions change (e.g. input voltage source changes, load changes, etc). The most popular feedback controller used in DC-DC converter is the frequency response. The main function of feedback controller is to compensate the converter shortcomings[7].

Figure 2.6: Feedback controller
2.5 PID Controller

PID controller is the one of the most common close-loop controller often utilized in industry. PID controller utilize a three main performance types P (proportional) for an overall control action, I (integral) to reduces steady-state errors and D (derivative) is seldom used on it's own in control systems it utilized to improves transient response. PID control is one of the oldest and classical controllers used for the boost converter. due to the various advantage of PID, it is widely used for industrial applications in the power electronic field. It uses one of the controllers including P, PD, PI, and PID. The PID utilized to develop the overshoot, transient response, and steady state error. The PID combining proportional, integral, and derivative together to get a stable output. It provides excellent control behavior of boost converter by obtaining the gain value of P, I and D. Figure 2.7 shows the circuit of PID controller[8].

![PID Controller Diagram](image)

Figure 2.7: PID Controller

2.6 Tuning of loop

As one knows the controlled process input can be unstable when the PID controller parameters such as the proportional gain, integral gain, derivative gain when they are not chosen correctly. Tuning a controller is just the adjustment of the control parameter to an optimum value to obtain the desired control response. Generally, the stability of the output response is required but at the same time the process must no oscillate for other combination of process condition and set point. There are different methods for tuning PID loops such as the Ziegler-Nichols, tune by feel, software tools and also the Cohen-coon method. All these methods have
their own advantages and also its disadvantages as done by previous researches[9]. Table 2.1 shows the effect of parameters.

**Table 2.1: The effects of increasing the parameters**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Rise time</th>
<th>Overshoot</th>
<th>Settling time</th>
<th>Steady-state error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportional gain</td>
<td>low</td>
<td>high</td>
<td>Small change</td>
<td>low</td>
</tr>
<tr>
<td>Integral gain</td>
<td>low</td>
<td>high</td>
<td>high</td>
<td>Eliminate</td>
</tr>
<tr>
<td>Derivative gain</td>
<td>Small change</td>
<td>low</td>
<td>low</td>
<td>None</td>
</tr>
</tbody>
</table>

### 2.7 Ziegler-Nichols method

Ziegler-Nichols method, introduced by John G. Ziegler and Nathaniel B. Nichols. As in Ziegler-Nichols tuning method, the I and D gains are first set to zero. The "P" gain is increased until it reaches the "critical gain" Kc at which the output of the loop starts to oscillate as shown in figure 2.8 [10]. Kc and the oscillation period Pc are used to set the gains as shown in the table below.

**Table 2.2: Ziegler-Nichols Method**

<table>
<thead>
<tr>
<th>Control type</th>
<th>$K_p$</th>
<th>$K_i$</th>
<th>$K_d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>0.5Kc</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PI</td>
<td>0.45Kc</td>
<td>1.2Kp/Pc</td>
<td>-</td>
</tr>
<tr>
<td>PID</td>
<td>0.6Kc</td>
<td>2Kp/Pc</td>
<td>KpPc/8</td>
</tr>
</tbody>
</table>