ANALYSIS OF PERTURB & OBSERVE (P&O) ALGORITHM FOR BUCK-BOOST CONVERTER

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DECLARATION

I declare that this thesis entitled "ANALYSIS OF PERTURB & OBSERVE (P&O) ALGORITHM FOR BUCK-BOOST CONVERTER is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : *farhan*

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APPROVAL

I hereby declare that I have checked this report entitled "ANALYSIS OF PERTURB & OBSERVE (P&O) ALGORITHM FOR BUCK-BOOST CONVERTER" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours.

Signature : ....

Supervisor Name : Siti Azura Ahmad Tarusan

Date : 6/7/2021

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Photovoltaic power systems are one of today's most rapidly growing technologies in renewable energy. DC-to-DC converters are commonly used for generating desired output in renewable energy applications. For instance, the photovoltaic power system supplies the DC-to-DC converter with energy, producing the desired voltage at the load. The buck-boost converter is selected in this project. The buck-boost converter also used in applications for power amplifiers and adaptive control applications. One of the photovoltaic power system flaws is the temperature and irradiance is always changing because of weather or surrounding condition. So, the Perturb an Observe method is implemented in this project to extract maximum power from the photovoltaic power system. Next, the photovoltaic power system produces too high or too less voltage for the load. The voltage from the photovoltaic power system must decrease or increase in order to meet the desired output. So the buck-boost converter is selected in this project. The aims of this project which are are to design buck-boost converter. Next, to investigate and compare the conventional buck-boost and non-inverting buck-boost converters. Then, simulating the buck-boost converter via the Simulink to analyze voltage, voltage ripple, current and current ripple. In this project, the conventional and non-inverting buck-boost converter were simulated in Simulink using the same value of inductor, capacitor and resistor. From the result, the non-inverting buck-boost converter has the best performance in aspect of voltage, voltage ripple, current and current ripple.

ABSTRAK

Sistem kuasa fotovoltaik adalah salah satu teknologi yang paling pesat berkembang pada masa kini dalam tenaga boleh diperbaharui. Penukar DC-ke-DC biasanya digunakan untuk menghasilkan output yang diinginkan dalam aplikasi tenaga boleh diperbaharui. Sebagai contoh, sistem kuasa fotovoltaik membekalkan penukar DC-ke-DC dengan tenaga, menghasilkan voltan yang diinginkan pada beban. Penukar buck-boost dipilih dalam projek ini. Penukar buck-boost juga digunakan dalam aplikasi untuk penguat kuasa dan aplikasi kawalan adaptif. Salah satu kelemahan sistem kuasa fotovoltaik adalah suhu dan sinaran selalu berubah kerana cuaca atau keadaan sekitarnya. Oleh itu, kaedah 'Perturb an Observe' dilaksanakan dalam projek ini untuk mengeluarkan kuasa maksimum dari sistem kuasa fotovoltaik. Seterusnya, sistem kuasa fotovoltaik menghasilkan voltan yang terlalu tinggi atau terlalu sedikit untuk beban. Voltan dari sistem kuasa fotovoltaik mesti menurun atau meningkat untuk memenuhi output yang diinginkan. Oleh itu, penukar buck-boost dipilih dalam projek ini. Tujuan projek ini adalah untuk membina penukar buck-boost. Seterusnya, untuk menyiasat dan membandingkan penukar buck-boost konvensional dan tidak-berubah. Kemudian, mensimulasikan penukar penambah wang melalui Simulink untuk menganalisis voltan, voltan riak, arus dan arus semasa. Dalam projek ini, penukar buck-boost konvensional dan tidak-berubah disimulasikan di Simulink menggunakan nilai induktor, kapasitor dan perintang yang sama. Dari hasilnya, penukar buck-boost yang tidak terbalik mempunyai prestasi terbaik dalam aspek voltan, voltan riak, arus dan arus semasa.

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LIST OF SYMBOLS AND ABBREVIATIONS

PV	-	Photovoltaic
DC	-	Direct Current
MPP	-	Maximum Power Point
MPPT	-	Maximum Power Point Tracker
P&O	-	Perturb & Observation
MOSFET	-	Metal-Oxide Semiconductor Field-Effect Transistors

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Renewable energy is one of the energy that on the rise worldwide nowadays. Renewable energy is produced by sources that naturally fill up and never exhaust. Sun, wind, geothermal and biomass are the most prevalent sources. One of the fastest developing technologies of renewable energy today, is the photovoltaic system.

PV solar panel supplies energy to the DC-to-DC converter to produce desired DC voltage to the load. One of the DC-to-DC converter is buck-boost converter. The buck-boost converter is a device that can generate output voltage that is either higher or lower than the input voltage.

The buck-boost converter is used in the self-regulating power supplies. It also used in the battery-powered systems where input voltages can differ widely, starting at maximum charge and then decreasing over time as the battery charge depletes. Furthermore, it is also used in power amplifier applications and applications for adaptive control.

The advantages of buck-boost converter are it can step-up or step-down voltages using minimum number of components while also providing a lower operating duty cycle and higher efficiency across a wide range of input and output voltages. The cost and complexity of the converter can be minimized due to the small number of components, Buck-boost converters also provide a more efficient solution with fewer and smaller external components [5].

1.2 Problem Statement

The power from solar panel is affected by the change in weather conditions such as rain, cloudy, haze and many more. This weather condition affects the irradiance and temperature that the solar panel receive. MPPT is utilised for the extraction and transmission of the greatest power from the solar panel. The Perturb and Observe algorithm is one of the MPPT algorithm. This algorithm operates by disrupting the device by increasing or reducing the operating voltage of the PV module and by analysing its effect on the module's generating power.

Next, the solar panel generate voltage that too high or too low for the load. In order to meet the desired output, the voltage from solar panel have to step down or step up. The desired output is high voltage output (200V) for high voltage load such as air-conditioner, washing machine and water pump. The other desired output is low voltage output (12V) for low voltage load such as battery charger. The buck-boost converter is selected because it able to increase or decrease output voltage by using a smaller number of components. There are two topologies of buck-boost converter that will be compared in this report. The two topologies are conventional buck-boost converter and non-inverting buck-boost converter. The conventional buck-boost converter produces different output voltage polarity than input voltage. The non-inverting buck-boost converter produces same output voltage polarity with the input voltage.

1.3 Objective

The objectives of this project are:

i. To design buck-boost converter and non-inverting buck-boost converter by using Simulink.

ii. To analyse the performance between conventional and non-inverting buck-boost converter in aspect of voltage, voltage ripple, current, and current ripple.

iii. To design buck-boost converter and non-inverting buck-boost converter with Perturb and Observe method by using Simulink.

iv. To analyse the performance between conventional and non-inverting buck-boost converter with Perturb and Observe method in aspect of voltage, voltage ripple, current, and current ripple.

1.4 Scope

The scope for this project is the PV power system produce same voltage input (100V). Then, two output voltage from the buck-boost converter that is high voltage (200V) and low voltage (12V). The DC-to-DC converter is buck-boost converter and non-inverting buck-boost converter. The Perturb and Observe method is applied in the MPPT algorithm. Next, using Simulink to simulate the buck-boost converter and non-inverting buck-boost converter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will show literature reviews are carried out by examining verified materials like as articles, research papers and books before beginning with this project. Reviews on related research regarding on the buck-boost converter for PV application was analyzed with distinction within each other.

2.2 Maximum Power Point Tracking (MPPT)

The power output from PV varies continuously because of the variation of irradiation ad temperature. MPPT is used to extract the maximum power from the solar panel and transferring that power to the load [12]. The basic MPPT algorithm are perturb & observe (P&O) method and incremental conductance [13,14]. This section will explain about these basic MPPT algorithm.

2.2.1 Perturb and Observe (P&O)

A frequently popular technique to MPPT is the P&O technique. As the name indicates, this technique works by interrupting the system, raising or lowering the PV module's operating voltage and measuring its influence on the power output of the panel. As demonstrated in figures 2-1, the PV regulator modifies the output of the PV module by a little bit in each control cycle. The control parameter can be both the output voltage and current of the PV panel, which is why it is termed "perturbation." In comparison of the PV-array power of the cycles, this method is thus the highest power level. The flowchart of the P&O method is shown in Figure 2-1 [6].

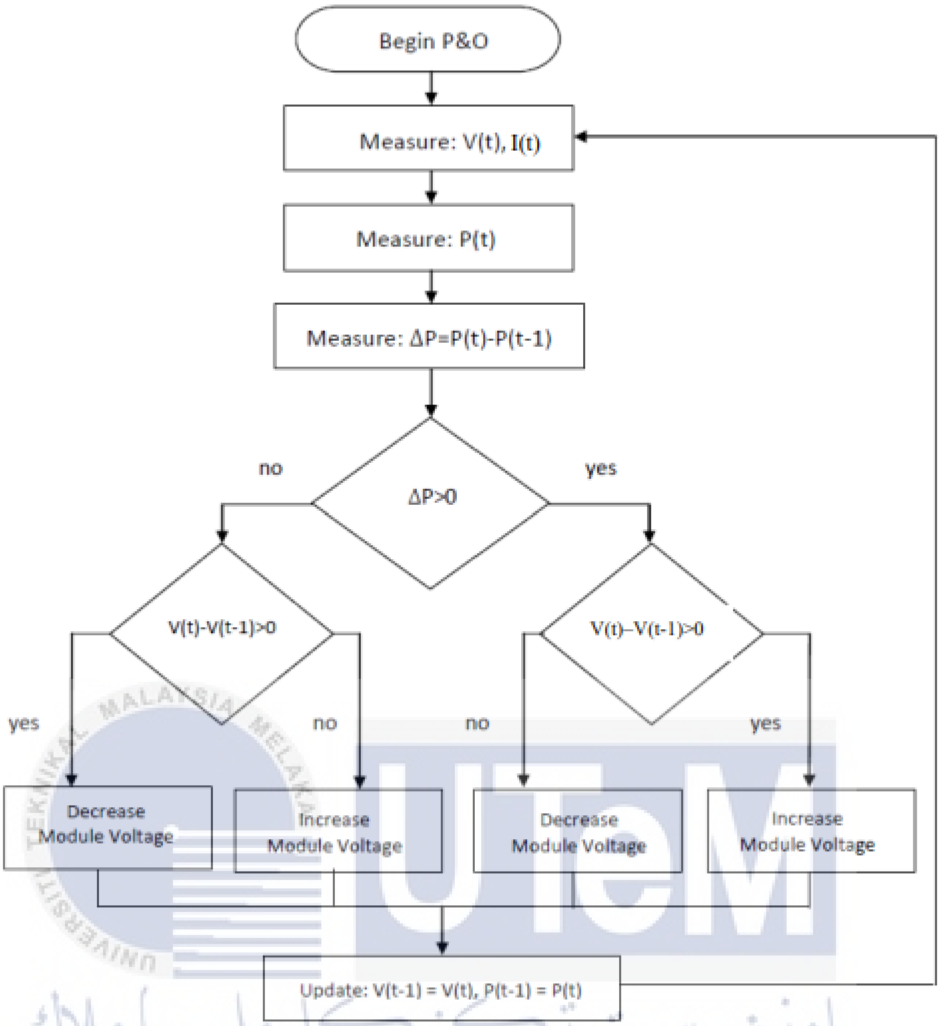

Figure 2-1 Flowchart of P&O method [6]

$\Delta P = P(k) - P(k-1)$

$\Delta V = V(k) - V(k-1)$

The duty cycle is reduced when ΔP and ΔV are positive [6].

$D = D - \Delta D.$

Duty cycle is increases when ΔP is positive and ΔV is negative [6].

$D = D + \Delta D.$

This is done on several occasions by tracking the maximum power point and maximising the power output of PV systems [6].

2.2.2 Incremental Conductance

Incremental Conductance can decide whether the MPPT achieves the MPP and terminates the interruption of execution. With great precision, this algorithm can swiftly monitor and decrease irradiation conditions. Buck-Boost Converter's higher complexity is the downside of this approach. The Incremental Conductance Algorithm flowchart is shown in Figure 2-2.

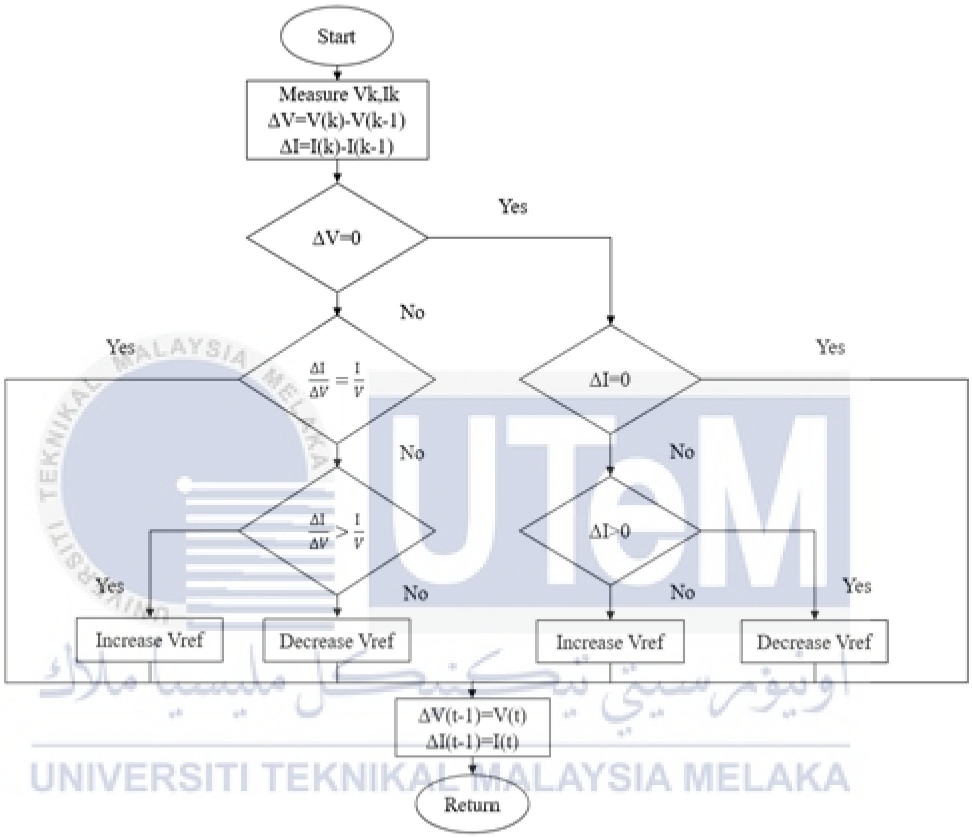

Figure 2-2 Flowchart of incremental conductance [18]

The technique starts with the value of I(k) and V(k) and then the voltage and the present variable are equivalent to 0 so that the PV operates on the MPP. The technique of this approach uses the previous values of the end of the cycle, I(k-I) and V (k-I). If the PV array does not function on an MPP, the changing parameters of the atmosphere are sensed using (dI≠0). If the increment of the current is positive, the voltage rises and otherwise the voltage will be lowered, depending on dI is positive or negative. The voltage variable is uniform to zero and compares dI/dV to I/V [18,19,20].

The MPPT control comprises of voltage and current MPPT inputs of the Photovoltaic modules that regulate the DC-DC converter's duty ratio. Through the DC-DC converter duty ratio as a control variable with P&O as the following control law, the problem of optimizing output energy may thus be successfully resolved [18].

$$Dk = Dk{-}1 + C1\,\frac{\Delta Pk{-}1}{\Delta Dk{-}1}$$

In spans K and K-1, Dk and Dk-1 are duty ratio values.. ΔPk-1/ΔDk-1 is the pivotal pitch is the PV power pitch in steps K-1 and C1 [11,16].

Incremental Conductance can quickly track and detect greater precision radiation conditions than P&O. The downside is the increasing complexity of this method [15,16,17].

2.3 Buck-Boost Converter

This part shows two type of buck-boost which are conventional buck-boost and non-inverting buck-boost.

2.3.1 Conventional Buck-Boost Converter

This section will explain the operation and mathematical equation of conventional buck-boost. Figure 2-3 shows the circuit diagram of buck-boost and Figure 2-4 display the equivalent circuit when switch closed.

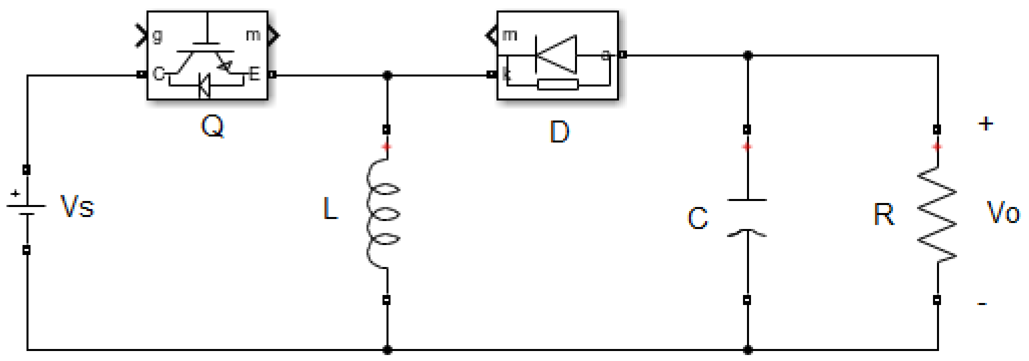

Figure 2-3 Circuit diagram of buck-boost converter

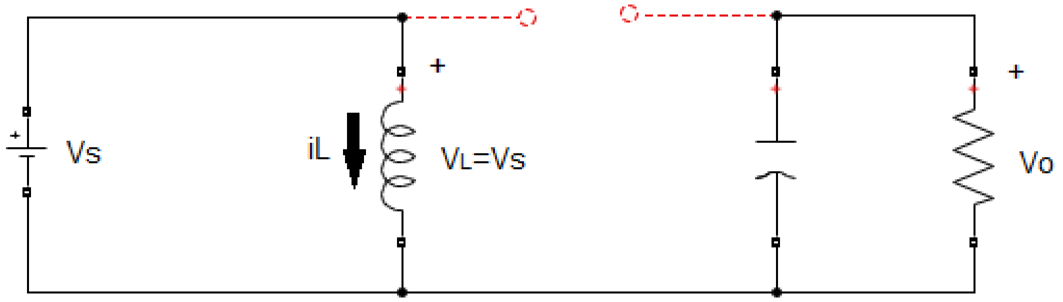

Figure 2-4 Equivalent circuit when switch closed

When the switch is closed (ON), the current to the inductor increases. The inductor will absorbs energy and charging during this period (charging mode). Voltage across inductor will be same with voltage supply [1].

$$VL = VS = L\frac{di\,L}{dt}$$

$$\frac{di\,L}{dt} = \frac{\Delta iL}{\Delta T} = \frac{\Delta iL}{DT} = \frac{Vs}{L}$$

$$(\Delta iL)\ \text{closed} = \frac{VsDT}{L}$$

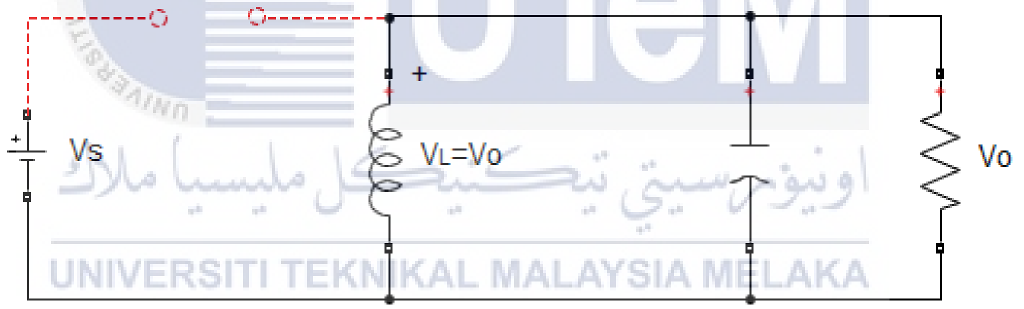

Figure 2-5 Equivalent circuit when switch open

When the switch is open (OFF), the inductor current will discharge to the capacitor and resistor (discharge mode) resulting in a decreasing inductor current. During this time, the polarity of the inductor reverses. The diode will be forward biased. The capacitor will filter out the ripple and stores energy [1].

The charged capacitor starts discharging through load resistor when switch is closed (ON) [1,3]. The voltage across the resistor is opposite polarity compared to input voltage [1].

$$V_L = V_O = L\frac{di\,L}{dt}$$

$$\frac{di\,L}{dt} = \frac{\Delta iL}{\Delta T} = \frac{\Delta iL}{(1-D)T} = \frac{Vo}{L}$$

$$(\Delta i_L)_{open} = \frac{Vo(1-D)T}{L}$$

The current during ON state is equal to OFF state[1].

$$(\Delta iL)\ closed + (\Delta iL)\ open = 0$$

$$\frac{VsDT}{L} + \frac{Vo(1-D)T}{L} = 0$$

$$V_o = -V_S\left(\frac{D}{1-D}\right)$$

The circuit will operate in boost mode when the duty ratio $D>0.5$ and the circuit will operate in buck mode when the duty ratio $Do<0.5$. Average source current is related to average inductor current [1].

$$I_S = I_L D$$

Power output equal to power supply [1].

$$P_O = P_S$$

$$\frac{Vo^2}{R} = V_S I_L D$$

Since $V_o = -V_S\left(\frac{D}{1-D}\right)$

$$I_L = \frac{VsD}{R(1-D)^2}$$

Maximum and minimum inductor currents [1]

$$I_{max} = I_L + \frac{\Delta IL}{2} = \frac{VsD}{R(1-D)^2} + \frac{VsD}{2L}$$

$$I_{min} = I_L - \frac{\Delta IL}{2} = \frac{VsD}{R(1-D)^2} - \frac{VsD}{2L}$$

$$I_{min} = 0$$

$$L_{min} = \frac{(1-D)^2R}{2f}$$

Output voltage ripple [1]

$$|\Delta Q| = \left(\frac{Vo}{R}\right)DT = C\Delta V_o$$

$$\Delta V_O = \frac{VoDT}{RC} = \frac{VoD}{RCf}$$

$$\frac{\Delta Vo}{Vo} = \frac{D}{RCf}$$