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Analysis and Design of Dynamic Buck Converter with Change in Value of Load Impedance

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Abstract

DC-DC Converter is a tool that is able to use for changing value of DC voltage to another value. DC-DC Converter commonly used in electronic system, for instance Personal Computer, telecommunication system, driver motor DC, and also used as charge controller for battery. This equipment is able to replace voltage regulator which has so much power dissipation. DC-DC converter has some of types; those are Buck Converter, Boost Converter, and Buck-Boost Converter. Each type of DC-DC Converter has their respective functions.

Buck Converter is useful as step down of the voltage value, so the output voltage will be decreased. DC-DC Converter of this type commonly used when the supply voltage from the source is too much for an electronic system as when the charging battery by solar panel, by using Buck Converter when supply voltage from solar panel exceed battery voltage charging then the voltage can be dropped to the value of battery charging. Therefore, battery lifetime can be safe, and also other electronic devices which use Buck Converter.

Buck converter has some primary components in its implementation, that is, MOSFET as fast as electronic switching, diode, inductor, and capacitor. To acquire, the optimal result should be noted the proper component selection. In this research, the writer tried to select inductance value of inductor and capacitance value of capacitor by simulating on MULTISIM, in order to get output as well as theoretical calculation and analyze the transient-state and the steady-state of the Buck Converter output. On the other hand, this research was conducted several variations of load for selected inductor and capacitor.

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Keywords: DC-DC Converter, Buck Converter, Power Transmission;

1. Introduction

Nowadays, the development of power transmission grows rapidly along with power supply needs of the electronic devices. In general, power transmission divided into two categories, those are AC to DC, and DC to DC, called AC-DC and DC-DC Converter respectively [1]. DC-DC divided into three groups based on their usability, which are Buck Converter that has a function to decrease the voltage, Boost Converter that has a function to increase voltage, and Buck Boost Converter that has a function to decrease and to increase voltage from the source [1] [2]. To determine the most suitable converter type, a review of power supply and electronic device that will receive power from the source is required. This paper would analyze Buck Converter circuit that would be used to decrease the voltage from the source, in the form of solar panel to charge the power of battery at the certain voltage [3] [4].

In a Buck Converter Circuit there are components such MOSFET as electronic switching, diode, inductor and capacitor [3] [4]. In this circuit, the value of the capacitance of the capacitor and the inductance of the inductor must be determined. Therefore, some combinations of the capacitance value of the capacitor and the inductance of the inductor that were obtained from the previous projects are used in this study. The simulation of the designed circuit was performed using MULTISIM software in this study. The state of transient and the state of current steady output of Buck Converter would be analyzed and observed in this simulation. Furthermore, the load resistance would be changed for various inductors and capacitors value that has been selected.

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2. Buck Converter Modeling

Buck conveter is a type of DC-DC converter that has a function to decrease an input DC voltage into higher DC voltage [3]. This converter circuit consists of MOSFET that is used as switch controller, a diode, inductor, and filter circuit which consists of capacitor and load resistor. Buck Converter using PWM (Pulse Width Modulation) as the switching signal to determine the length of the switching on/off time[4].

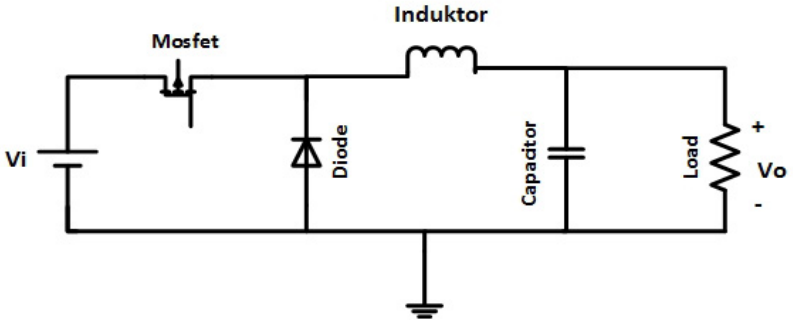


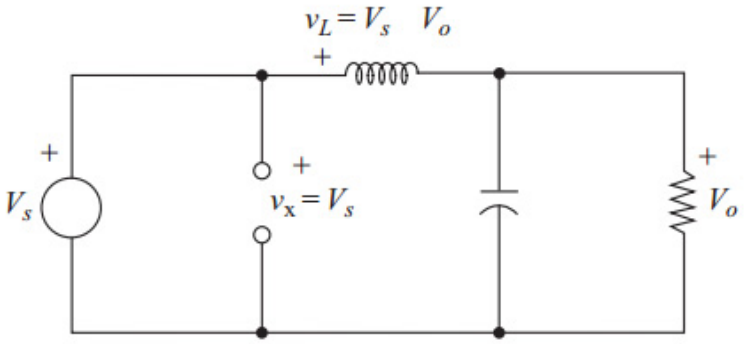
Fig. 1. Buck Converter Scheme [1]

The output voltage of Buck Converter is controlled by controlling state on/off switch in circuit. [3]. MOSFET was used as an electronics switch in Buck Converter while PMW was a control signal that used to control on/off state on the MOSFET.

Buck Converter has an average voltage value that is equal to a ratio between closing time of active switch of the period of its switch (work factor). This work factor value is always in the range of zero to one, so the average value of the output voltage generated is always lower than the input voltage.

2.1. Buck Converter Operating Principle

There are two working states: when the switch is closed or when mosfet is in saturation region, and when the switch is open or when mosfet is in region cut-off.



- Closed Switch

Fig. 2. Buck Converter: Closed Switch [1]

When the switch is closed, the current flows through the inductor and at the same time the dioda is in bias reverse condition, so the energy will be stored in the inductor. In this condition, a voltage in an inductor is shown in equation below [1]:

$$V_L = V_s - V_o = L \cdot \frac{di_L}{dt} \quad (1)$$

$$\frac{di_L}{dt} = \frac{V_s - V_o}{L} \quad (2)$$

The change rate of inductor current is constant, which it shows that the current of inductor increases linearly. The previous equation is stated as follows [1]: