DC to DC Buck Converter Design with Thin Film Solar Cells for Mobile Applications

Lin Htet Naung[1*], Than Than Htike[1]

[1] Department of Mechanical Engineering, Yangon Technological University, Yangon, Myanmar

Email Address

linhtetnaung.ytu@gmail.com (Lin Htet Naung)
*Correspondence: linhtetnaung.ytu@gmail.com

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Abstract:

The paper presents the DC to DC Buck Converter Design with Thin Film Solar Cells for Mobile Applications. The main research problem in this study is to get the maximum power because solar irradiation is always changing and the unstable output affected to damage the storage battery while the charging process is started. The objective and solution for this challenges are to get the relevant output from PV using with switching mode converter (DC to DC converter) with various kinds of input voltages. The theoretical simulation for DC to DC buck converter design was carried out with the help of circuit simulation software for the confirmation of experimental studies. The results confirm that the developed and proposed buck converter design met the performance specifications for the real world applications.

Keywords:

DC to DC Converter, Buck Converter Design, Circuit Simulation, Theoretical Calculation, Thin Film Solar Cells, Mobile Applications

1. Introduction

All electronic devices are operated some supply voltages which is generally assumed constant. The voltage regulator is an electronic circuit that supporting to the constant output voltage. Various types of voltage regulators and many control methods were used to regulate output. In the DC to DC converter, the converter input is unregulated dc, and outputs are regulated dc. There are several types of conversion procedures such as switched-mode, electronic, magnetic, linear, and capacitive.

Mobile applications with renewable energy system developments are vital role to enhance the power electronic technology in real world applications such as smart environments, smart systems and smart technology. Numerous DC-DC converters are accessible either to increase or to decrease the voltage from source to the point of efficacy. Selecting finest appropriate converter depending on the application is very essential. Converters selected should have high operating efficiency, low cost, modest in construction. Many converters employ low switches to reduce the losses [1-2]. Design of any converter depends on duty cycle [3]. Buck converter is exact simple in construction and can successfully decrease the voltage level available at source to the voltage level which is obligatory at the point of usage [4]. The key concept which should be kept in mind while conniving a converter is the device reverse voltage, forward voltage drops and forward current.

Buck converter effectively step-down the level of voltage but the Buck circuit consists of diode. When the main switch is on, the diode does not conduct. But when the diode starts conduction, the losses that occur in diode, called conduction losses increases when the ON time of diode increase. Due to these conduction losses in diode, the efficiency of the converter might decrease. To increase the efficiency reducing the conduction losses, this paper proposes Synchronous Buck converter where the diode in the Buck converter is replaced with another switch in Synchronous Buck converter. The two switches in Synchronous converter are synchronously operated such that no overlap takes place in their ON time.

The paper is organized as followed. Section 2 presents the DC to DC Buck Converter Design. Section 3 mentions the implementation of DC to DC buck converter. Section 4 gives the results and discussions and conclusion is offered in section 5.

2. DC to DC Buck Converter Design

Figure 1 shows the fundamental concepts of the DC to DC converter design for power electronics conversion techniques [5-8]. The functional operation of buck converter mainly depends on the charging of inductor through switch and discharging of inductor through diode. While inductor is being discharged through diode, diode conducts over a period of time. Diode will have high conduction losses and these losses makes efficiency low. So due to the diode conduction, efficiency of buck converter is low.

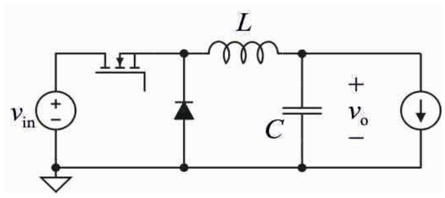

Figure 1. *DC to DC Buck Converter.*

This problem can be eliminated if we can replace this diode with a switch having less conduction losses. This replacement of diode with a switch makes synchronous buck converter. Since the conduction time of the secondary switch S_2 is high when compared to S_1, there will be losses present across switch S_2 and this is the main criteria why we are going for synchronous buck converter. There are two switches in that circuit and two switching states with continuous inductor current could be worked as in Figure 2.

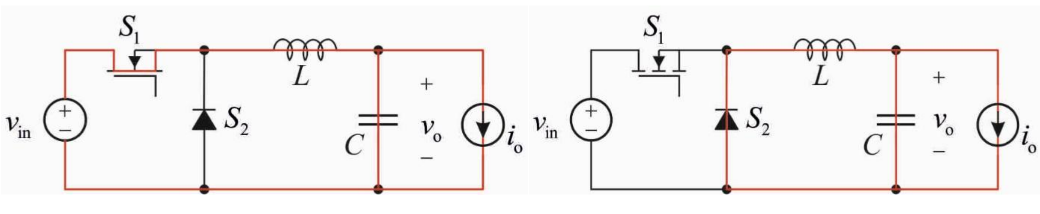

Figure 2. Two switching states (with continuous inductor current) (a) S_1 ON, (b) S_2 ON.

Both buck converter and synchronous buck converter is similar in operation but with diode in buck converter will be replaced with a switch in synchronous Buck converter.

3. Implementation

Figure 3 shows the Proposed Converter System. There are four main components in that diagram. The solar thin film, DC to DC converter, PWM controller and the load or battery are the important parts in mobile application system. The DC to DC converter is the main portions in that system for theoretical analyses.

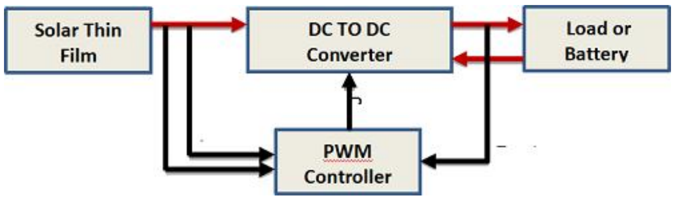

Figure 3. *Proposed Converter System.*

Figure 4 demonstrates the Buck Converter with 16V Input. The analysis is only checked the output voltage levels for the control of buck converter circuit.

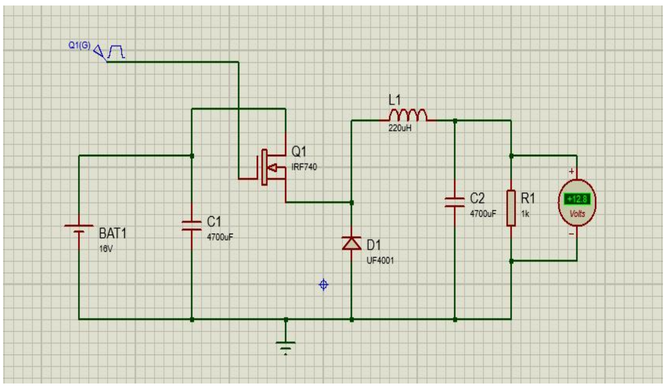

Figure 4. *Buck Converter with 16V Input.*

Figure 5 illustrates the Buck Converter with 24V Input. The optimum output voltage level is achieved in that analysis.

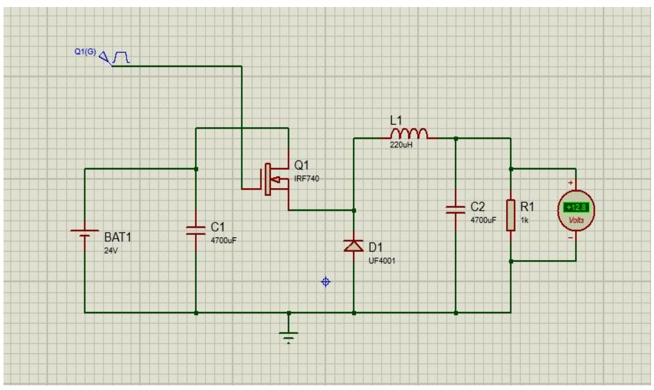

Figure 5. *Buck Converter with 24V Input.*

Figure 6 mentions the Buck Converter with 10V Input. If the voltage in output terminal was decrease, the buck converter could be affected to convert the input voltage for real usages.

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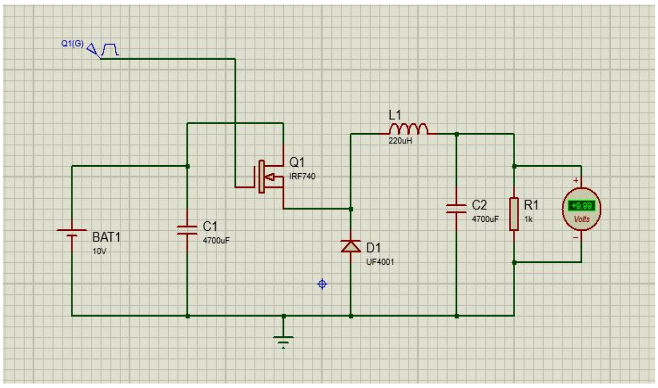

Figure 6. *Buck Converter with 10V Input.*

Figure 7 presents the Checking Duty Cycle in DC to DC converter. The duty cycle for the PWM controller could be calculated with equation (1).

D=V0/Vin (1)

D=12.8V/24V=0.53~0.6

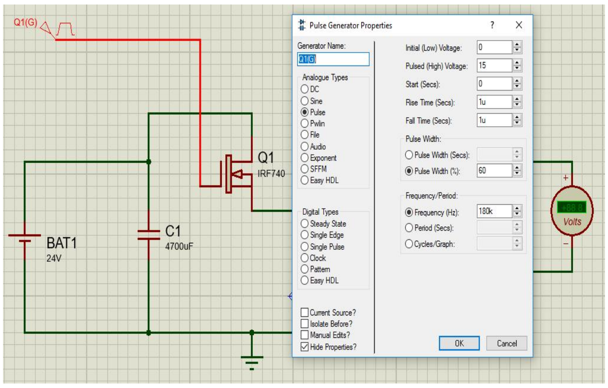

Figure 7. *Checking Duty Cycle.*

4. Results and Discussions

Using amorphous thin film solar cells will efficient for portable DC voltage applications but the voltage from thin film is too low so wire connection is greatly care between thin film connection and to and from the circuit. For military, power consumption is challenge for communication. Infantry soldiers will need to carry easily for their power available source. For these issues, this system may be solved with efficient energy consumption This buck converter will usable for maximum 24 V input so we can use for 24 V battery to 12 V charging.

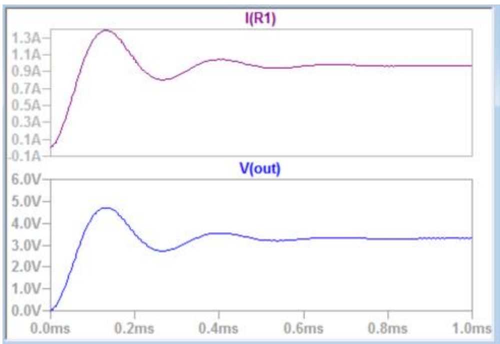

Figure 8. *Output Voltage and Current of the DC to DC Buck Converter.*

In this converter, constructing components values are easily to receive in commercial market. In this paper, the model of synchronous Buck converter was presented with its design. Normal buck converter was also dis-cussed with its output results. Circuit Simulation model of synchronous buck converter with both open loop and closed loop operation was presented along with its results. Figure 8 illustrates the Output Voltage and Current of the DC to DC Buck Converter.

5. Conclusions

DC-DC converters play a very vital role in many of the applications especially in the field of power supply to low power requirements. The efficient DC to DC buck converter design for specific application was designed, modelled, and analyzed. Buck converter steps down the voltage to desired level at the output. But due to the usage of diode in its circuit operates the converter with losses due to so called conduction losses in diode. To minimize the conduction losses, the diode is replaced with a MOSFET switch which has very less conduction losses when compared to diode. The results of developed DC to DC buck converter were met the performance specification for practical usages.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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