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Development of Buck-Boost DC-DC Converter Using LNK3204 Linkswitch IC

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Abstract: A DC-DC Buck-Boost converter is usually used in power electronic devices such as step-up or step-down as DC supply voltage to produce the voltage level required by the device's component. The complexity of the converter also can make the Buck-Boost system difficult to maintain. To solve the complexity in this DC-DC Buck-Boost converter is using LNK3204 IC which is a build-in offline switch IC. The main objective of this project is to analyze the performance of the output voltage ripple by developing a prototype for this circuit and to analyze DC output voltage based on feedback current. By using LNK3204 IC it will save space that the PWM signal has built-in in the IC. The testing result shows the buck-boost dc-dc converter using LNK3204 IC can work in both conditions with better output voltage ripple with different values of the control resistor.

Keywords: Buck-Boost DC-DC Converter, LNK3204 IC, Output Voltage Ripple

1. Introduction

Day by day, batteries are one of an important part of a lot of applications such as our electronic devices i.e. smartphones and laptops, they are also needed in renewable energy such as photovoltaic system, electrical vehicles and in our remote control [1]. Power electronics are precise modeling tools capable of reproducing even the small-scale features of the steady-state and transient responses of the output guarantee schemes. In power converter, it has 4 types such as DC converter, rectifier, inverter and frequency converter [2]. In this project, the buck-boost dc-dc converter has been chosen because it have a lot of advantages such as high power density, high output efficiency and high reliability which widely utilize in industrial technology [3].

A dc-dc buck-boost converter usually use in power electronic devices which is to step up or step down the output voltage to produce a suitable voltage level that required by the devices or in their application [4]. But there is a restriction in this converter which is the component in this circuit must choose the right component value because it will give impact the ripple and cost of building the entire converter system. This circuit produces voltage ripple that give a negative impact on the lifespan of a battery [5]. Therefore, a high switching frequency is used to reduce this problem and can minimize the

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size of the converter. The complexity of circuit can make it difficult to maintain and to solve on this complexity is by using LNK3204 LinkSwitch IC.

In this project, it has three main objective that need to be achieve. First, to design a prototype of the Buck-Boost DC-DC converter using LNK3204 IC. Next is to analyses DC output voltage based on feedback current input. Lastly, to analyzes the performance of the voltage ripple of Buck-Boost DC-DC converter using LNK3204 IC. By using the LNK3204 IC, it will save space and, in the IC, it has their own protection if anything happens in the circuit. Using the LNK3204 IC in the buck-boost dc-dc converter will reduce the output voltage ripple in this circuit and output voltage can be change as change the value of the resistor that connected with the feedback pin of LNK3204 IC.

2. Materials and Methods

2.1 LNK3204 1C

The LNK3204 IC have the auto restart circuit as a protection from the short circuit and open loop fault for safety and reliable in this configuration. It also has output voltages protection and line input protection. This IC have high performances which can support a lot of topologies such as buck, boost, buck-boost and flyback and have can reduces size and cost of magnetics and output capacitor. Other features is low temperature variation and On-Off control that provided constant efficiency over a wide load range. Table 1 shows the features in LNK3204 IC [6].

Table 1: Features in LNK3204 IC

Attribute	Value
Regulator Function	Boost, Buck, Buck-Boost, Flyback
Efficiency	75%
Pin Counts	8
Maximum switching frequency	70kHz
Number of Output	1

As shown in Figure 1, there are 8 pins that build in LNK3204 IC which is includes with Feedback pin (FB), Bypass pin (BP), Drain pin (D) and lastly Source pins (S). All these types of pins have there on function in build circuit.

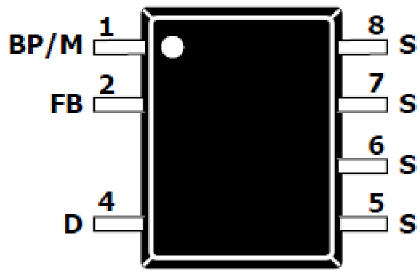

Figure 1: LNK3204 IC Pin Configuration

First pin is Feedback pin (FB). FB is used to control the power switching of the MOSFET and power MOSFET will terminated if the current of feedback, I_{FB} is larger have been delivered on this pin.

Next is Drain pin (D) which is used to provides internal operating current for start-up and steady stated operation which is connection of power MOSFET. For Bypass pin (BP) it has multiple functions such as bypass is the connection point for an external bypass capacitor, and it provides a shutdown function when it enters to Auto-restart which is used to provides an output over voltages protection functional with external circuit. And lastly, Sources pins (S). This pin is the connection of power MOSFET sources. Sources pin function is used to be ground references for the Bypass and Feedback pin in this configuration.

2.2 Circuit Design

Table 2 shows the specification of the parameters used in designing a buck-boost dc-dc converter using LNK3204 IC for this project.

Table 2: Parameter of Buck-Boost DC-DC Converter Circuit

Parameter	Value
Input Voltage (V)	12
Resistor, R1 (kΩ)	24
Resistor, R2 (kΩ)	Variable resistor (20)
Resistor, R3 (kΩ)	27
Inductance, L1 (mH)	1
Capacitance, C1 (nF)	100
Capacitance, C2 (µF)	10
Capacitance, C3 (µF)	100
Diode, D1	1N4004
Diode, D2	1N4004
Integrated circuit, IC	LNK3204

Based on the Figure 2, the variable resistor is use in this circuit is as the medium in control the PWM signal in changing either for buck condition or boost condition. Some of the parameters are fix regrading to the passive component used in this study implement such as value of three capacitance which is 100nF, 10µF and 100µF and inductance which is 1mH. The output voltage can in buck condition until 20% of duty cycle and boost until 80% of the duty cycle. With all this parameter, the circuit can be designing the circuit using Proteus software and PCB design in the same software. Figure 2 show the circuit design in the Proteus software and the PCB design in the same software. For the input supply and output of the system have been change with the terminal blocks as to make it easy to connect with power supply and load testing propose. Variable resistor is function as the controller in changing the condition either buck or boost condition in this circuit. As shown in Figure 2, the resistor, R2 is connected to Feedback pin of LNK3204 IC and in this system feedback pin is functional in controlling the power switching of the MOSFET which have been implement in this LNK3204 IC.

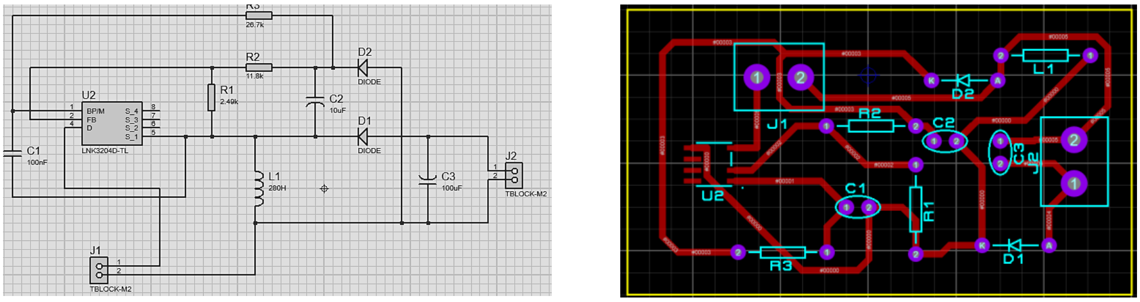

Figure 2: Circuit Design in Proteus and PCB Design in Proteus

3. Results and Discussion

3.1 Condition of Buck-Boost

The output voltage for this testing has been taken by using a multimeter which can be seen in the Table 3. From this table, this buck-boost dc-dc converter will in the buck condition if the value resistor is in low stated and will be in steady-stated condition when the resistor value is 10.54kΩ. When the value of the resistor is high from the value of the steady-stated, the circuit will operate in boost condition which is higher than 10.54kΩ.

Table 3: Condition of Buck-Boost DC-DC Converter Circuit

Condition	Resistor value, R2 (kΩ)	Output Voltage (V)
	7.15	-9.0
Buck	8.27	-10.0
	9.57	-11.0
Steady-stated	10.54	-12.0
	11.79	-13.0
Boost	12.80	-14.0
	13.86	-15.0

3.2 Current at Feedback Pin

Table 4 shows the value of the feedback voltage and feedback current at the feedback pin of the LNK3204 IC. The voltage in feedback pin is remain constant which is only 2V as stated in the Chapter 2 that the feedback input circuit on the feedback pin provides a low follower output of the impedance source set on the 2.0V only. From this testing is proved that the voltage on the feedback pin is will active when the feedback pin of the LNK3204 IC is receive the enough voltage. For the value of the resistor, R2 which is increasing accordingly the output voltage in this circuit.

Table 4: Feedback Voltage and Feedback Current at Feedback Pin

Input Voltage (V)	Feedback voltage (V)	Resistor Value, R2 (kΩ)	Feedback current, (A)	Output Voltage (V)
12	2	7.15	0.28	-9.0
12	2	10.54	0.19	-12.0
12	2	15.72	0.13	-18.0
12	2	21.53	0.09	-22.0

As shown in Figure 3 which is the graph of the feedback current at feedback pin versus the value of output voltage in this buck-boost dc-dc converter using LNK3204 IC. The current getting decrease when the output voltage is getting decrease and from the Table 4, when the output decreases, the value of the resistor R2 is increase.

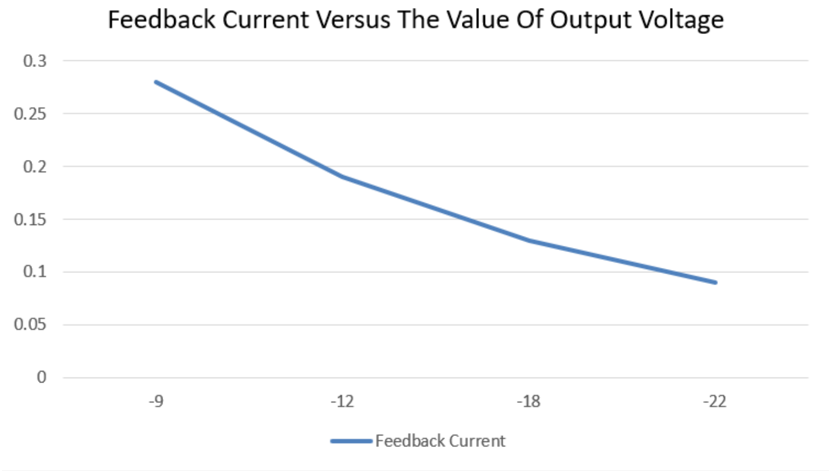

Figure 3: Feedback Current Versus the Value of Output Voltage

3.3 Output Voltage Ripple

As can be seen in Table 5 is the data that were collect from the testing in laboratory for output voltage, output voltage ripple and the percent of the voltage ripple per output voltage. This data is to analyses the output voltage ripple in this system which is in steady-stated condition, buck condition and boost condition.

Table 5: The output voltage, duty cycle and Output voltage ripple

Output Voltage (V)	Duty Cycle (%)	Resistor Value, R2 (kΩ)	Output voltage ripple (mV)	Vripple/Vout (%)
-9.0	42%	7.15	200	2.22
-12.0	50%	10.54	400	3.33
-18.0	60%	15.72	400	2.22
-22.0	64%	21.53	400	1.82

From Table 5, the changing in the resistor value of R2 which is increased will change the value of the output voltage in this system which is decreases accordingly changing of the duty cycle. The changing of the output voltage will affect the value of the output voltage ripple. When the circuit is in steady-stated condition, the output voltage ripple is 3.33% with the value of the resistor R2 is 10.54kΩ and will decrease the percentage value of the output voltage ripple in buck and boost condition. For buck condition, the duty cycle must be lower that 50% and the percentage value of the output voltage ripple will decrease when the duty cycle in this condition getting decrease. Same as in boost condition, it must higher than 50% of the duty cycle from the steady-stated condition. The percentage value of the output voltage ripple will decrease when the duty cycle getting increase and the output voltage will decrease. From the analysis, resistor R2 is the controller in this circuit which is in changing the output voltage and in reduce the percentage value of the output voltage ripple.

Figure 4 and Figure 5 show the graph of the output voltage of the -9V and -22V. From both Figure, the graph like a straight line because of the lower value of the ripple that produces in this circuit. For -9V which is in buck converter, the output voltage ripple produce is only 200mV and it really small to be read. For output voltage -22V which is in boost condition, the output voltage ripple that been produces is 400mV with the percentage value of the output voltage ripple is 1.82%.

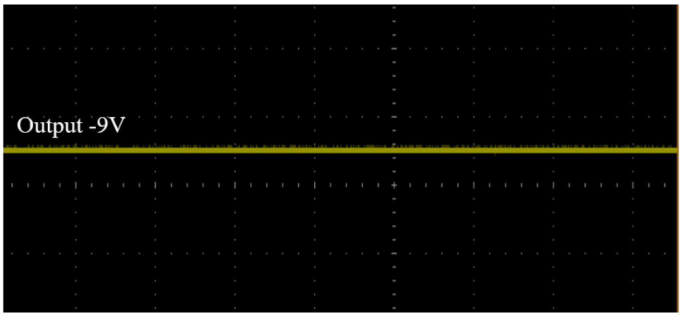

Figure 4: Graph of -9.0V from Oscilloscope

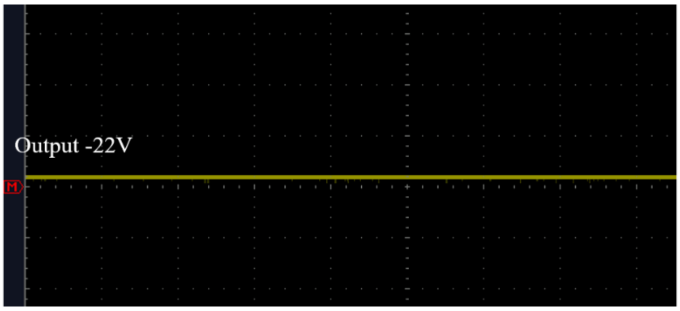

Figure 5: Graph of -22.0V from Oscilloscope

4. Conclusion

Overall, in this project, the buck-boost dc-dc converter using LNK3204 IC design is successfully developed according to specific parameter and using specific software which is Proteus before turning it into PCB design. This circuit able to produces output voltage in buck condition and in boost condition which is step up the input voltage in this circuit. Based on the result analysis showed the feedback current on the feedback pin is correlation with the output voltage in this system. When the value of resistor R2 in this circuit change which is increase, the value of current will change to with the decrease pattern of the value. This result is approved that the changing of the resistor R2 with fixed voltage at feedback pin can control the output voltage in this system. Lastly, this circuit will able produces the lower output voltage ripple when the output voltage is higher value in boost condition and lowest value of output voltage in buck condition. All these 3 objectives in this project have been successfully achieved with the suitable method that have been use.

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