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The Performance Analysis of Buck DC-DC Converter using LNK304 IC

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Abstract: A DC-DC Buck 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 system difficult to maintain. To solve the complexity in this DC-DC Buck converter is using LNK3204 IC 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 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, DC-DC Converter, LNK304, Offline Switcher, Efficiency, Voltage Ripple

1. Introduction

Industrial applications require many fixed voltage sources to be converted into a varied voltage source like a transformer that can step down the voltage source. The converter usage has been utilized in many applications with the contribution of AC and DC sources. It can be in the form of rectifier (AC-DC conversion), inverters (DC-AC conversion), step-up or step-down voltage (AC-AC conversion or DC-DC conversion). Developing an integrated circuit, IC converter using semiconductors has supported the fundamental of power electronics. The DC-DC converter can be designed into an IC, which can be multifunction and multi-usage with the combination of other components and placed into a printed circuit board (PCB) in the fabrication process. The IC can be operated in the buck, and buck-boost also can be combined with optocoupler usage.

The usage of the buck DC-DC converter, especially in the automotive industry accessories, has been widely used worldwide [1]. The increase in accessories design has increased the converter usage demand with many variations in required voltage. The conversion of a buck drops the voltage from the vehicle's battery to suit the electrical accessories appliance's required voltage. The usage of a buck

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converter also is an excellent alternative to the usage of a step-down transformer, and it can fully utilize the function of power electronic application.

The development of buck DC-DC converter requires a lot of components such as resistors, capacitors, inductors, and diodes. Choosing the correct value of components with a suitable tolerance is a must, especially in voltage, current, frequency and temperature. The increase in components value in the development of buck DC-DC converter might affect the efficiency and the cost of building the whole converter system [2]. The switch controller used to control the duty cycle of the buck DC-DC converter simultaneously increases the complexity of the system. The converter's complexity can also make the buck system hard to maintain [3]. However, the usage of LNK304 will reduce the system's complexity with the built-in offline switch in the IC.

The buck DC-DC converter has a high ripple output voltage, which might be unsuitable for applications that cannot exceed a specific voltage. It may cause the appliance to decrease its lifespan and low effectiveness [1]. However, this issue can be solved by choosing the suitable inductor and capacitor value for the filtering process.

This project is aimed to study develop and investigate the operation of buck DC-DC converter by using LNK304 IC. The technology of the buck DC-DC converter by using the feedback and drain concept replacing the MOSFET and external switcher. From this technology, the duty cycle is controlled automatically, and the voltage ripple is observed.

2. Materials and Methods

The development of the buck DC-DC converter using LNK304 requires a circuit to connect with correct resistors, capacitors and inductor values as shown in Figure 1. The component was also placed in the PCB board with correct polarity according to the buck DC-DC converter fundamental and an additional tier to provide feedback and protection using the LNK304 operation. The buck DC-DC converter is designed with components and its parameters shown in Table 1 with the PCB design in Figure 2.

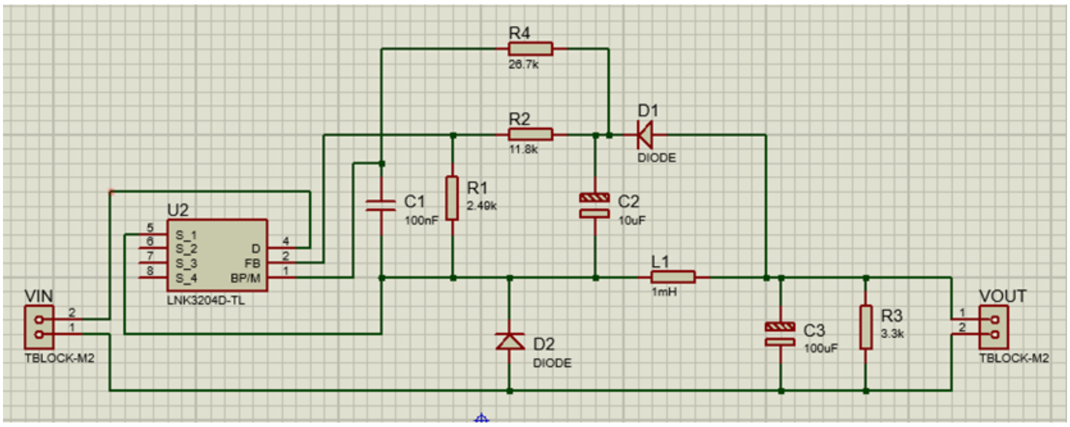

Figure 1: Design of the buck DC-DC converter circuit

Table 1: Component parameters for the initial setup

Item	Label	Value
Ceramic capacitor	C1	100nF
Electrolyte capacitor	C2	10uF
Electrolyte capacitor	C3	100uF
Inductor	L1	1.8mH
IN4004 Diode	D1, D2	
Resistor	R1	2.4kΩ
Resistor	R2	12kΩ
Resistor	R3	3.3kΩ
Resistor	R4	27kΩ
Terminal block	J1,J2	

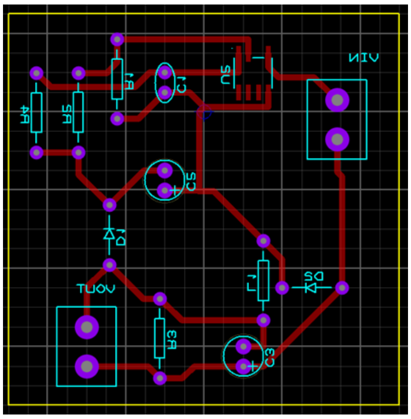

Figure 2: PCB design in Proteus software

The experiment setup is shown in Figure 3. The circuit design can be regulating the output voltage by varying one of the resistor values. Firstly, identify the resistor functionality in the circuit. Based on the observation, R1 and R2 are connected in parallel, considering the voltage divider. R1 and R2 are then varied by using a variable resistor. The output voltage is observed by connecting the R1 to the 10kΩ variable resistor and R2 is connected to the 50kΩ variable resistor to study the voltage ripple and the duty cycle.

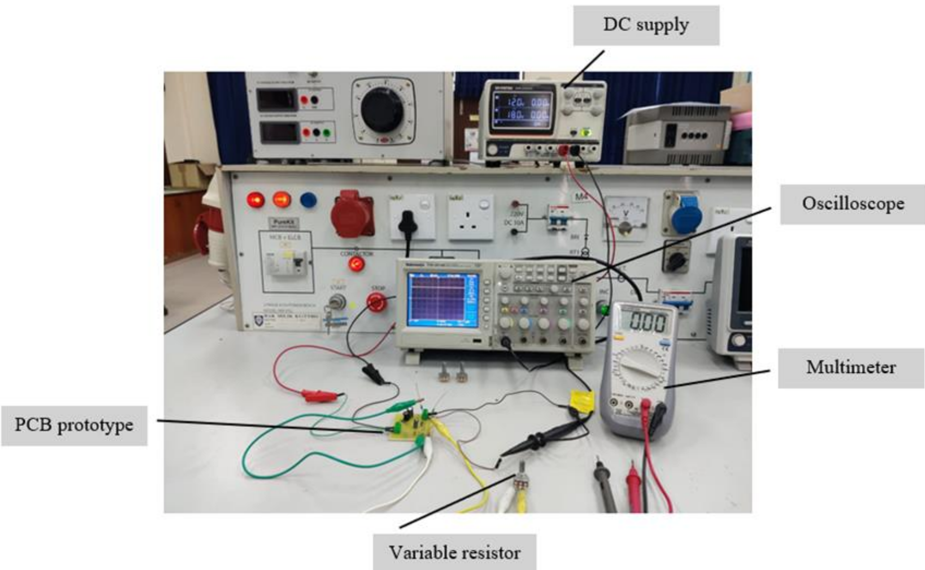

Figure 3: Buck DC-DC converter experiment setup

3. Results and Discussion

Designing the buck DC-DC converter using LNK304 is different compared to the conventional buck DC-DC converter. With the usage of the internal switching process, the duty cycle can be controlled by using the voltage divider resistors to control the output voltage.

3.1 Feedback functionality of the LNK304

The circuit is tested by disconnecting the R1 as the R1 and R2 are connected in a parallel connection. According to the buck DC-DC using the LNK304 concept, the R1 and R2 are selected to maintain 2V at the feedback pin. It is recommended that R1 be chosen as a standard 1% resistor of 2.4kΩ to ensure good noise immunity. The study of the feedback started by replacing R1 with the 10kΩ variable resistor. With the fixed input voltage of 12V, the output voltage is observed. Table 2 shows the variation in R1 affecting the output voltage, duty cycle and ripple voltage.

Table 2: R1 affecting the output voltage, duty cycle and the ripple voltage

Resistor value (kΩ)	Output voltage (V)	Duty cycle, D	V_{ripple} (mV)
2	6.8	0.57	80
4	6.32	0.53	103
6	7.76	0.64	365
8	6.48	0.54	147
10	7.68	0.6	160

The output voltage does provide a minor change with the change of R1 value. The output voltage also varied due to the unstable state of the noise. The duty cycle also can be unstable due to the unexpected regulation where the noise is interrupting the function of feedback in maintaining 2V feedback voltage. To observe the performance of the output voltage, the ripple voltage is measured. The noise in the ripple shows that the output voltage cannot be connected to the appliances due to the unstable which can cause damage and reduce the lifespan of the appliances.

3.2 Adjusting the duty cycle through resistors

R1 and R2 are connected through the voltage divider concept. The testing of adjusting the value of the resistor is to make sure that the output voltage can be regulated. The regulation of output voltage cannot be done without the PWM controlling the duty cycle. But in this case, the PWM is fixed, and the function of feedback and voltage divider resistors can be adjusted.

Another pair of R1 to form the voltage divider is R_2. The R_2 is regulated just like R_1. R_2 with the fixed value of 12kΩ is varied into 10kΩ, 20kΩ, 30kΩ, 40kΩ and 50kΩ and the output is observed in Table 3 The variation in R_2 is regulating the output voltage while the input voltage is maintained with 12V and R_1 is 2.4kΩ. Table 3 shows R2 value affecting the output voltage, duty cycle and the ripple voltage.

Table 3: R2 affecting the output voltage, duty cycle and the ripple voltage

Resistor value (kΩ)	Output voltage (V)	Duty cycle, D	V_{ripple} (mV)
10	6.4	0.53	80
20	6.8	0.56	80
30	6.88	0.57	80
40	7.2	0.59	80
50	7.28	0.6	80

The output voltage can be regulated through the variation in R_2. The duty cycle also can be varied with the chosen resistor value. Based on this voltage divider concept, the R_2 is controlling the output voltage by providing the reference voltage to the feedback pin. The output ripple is also stable with 80mV fixed and shows that there's almost no noise develops when R_1 is varied.

4. Conclusion

The aim of this project is achieved. The design of the circuit is based on the fundamental circuit that provided in the datasheet and a PCB design is printed to test out the circuit. The circuit is measured for the variation in R_1 and R_2. R_1 affects the noise of the circuit while R_2 regulates the output voltage. The duty cycle of the variation in R_1 is unstable due to the noise and the ripple voltage is also interrupted. So, choosing approximately 2.4kΩ resistor for R_1 is the best way to reduce the noise. In other to increase the output voltage, R_2 can be increased to increase the duty cycle. No noise has appeared when R_2 is regulated due to the fixed 2.4kΩ, R_1 value. As result, the ripple voltage turns out to be smooth with the right resistor adjustment.

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