A Constant and Adjustable Power Supply for E-cigarette Application by TPS61022

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ABSTRACT

This application report gives an E-cigarette power solution, which includes a Li-ion battery, a booster (TPS61022) and an atomizer (2Ω). This solution could support output power up to 12.5W (5V/ 2.5A) and could have adjustable output power function. By using a booster, E-cigarette Application could get a much higher and more constant power supply, which could give a better taste of smoking. The adjustable output power function makes E-cigarette design more flexible.

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1 Introduction of E-cigarette

An electronic cigarette or e-cigarette shown in Figure 1, is a handheld electronic device that simulates the experience of smoking a cigarette. The e-cigarette is considered less harmful as compared to tobacco cigarettes and could help smoker quit. Because the e-cigarette has the benefits such as zero smoke, no pollution, reduces health-related problems, and can be smoked at public places. See References

E-cigarette components include a mouthpiece, a cartridge (liquid storage area), a heating element/atomizer, a microprocessor, a battery, and some of them have a LED light on the end. The e-cigarette uses the battery to power the atomizer and heat e-liquid. Normally, the resistance of atomizer coils vary from 0.4 Ω to 2.8 Ω. It is easy to power the atomizer by the battery directly and use a power MOS to adjust power. But the maximum power is limited because of battery voltage. And another disadvantage is battery voltage is not constant and causes output power to vary, which will influence the taste of smoking.
2 TPS61022 Device Overview

TPS61022 has a minimum 6.5-A valley switching current limit over full temperature range, which could support output power up to 12.5W. TPS61022 has a 12m Ω lowside MOS and a 18m Ω highside MOS, which could help gain high efficiency, eg. 95% efficiency at Vin=3.6V Vout=5V and Iout=2.5A. The typical start-up capacity of TPS61022 is 1 Ω, which could startup with the resistance of atomizer is higher than 1 Ω. TPS61022 operates at 1-MHz switching frequency and has a small package size (2mm*2mm VQFN), which could has smallest total solution size. See further details on the datasheet.

3 System Overview

The E-cigarette atomizer power solution is shown in Figure 2. The output power adjustable function is implemented using PWM to control EN pin. The MODE pin is connecting to GND (setting to low logic level), the TPS61022 converters operates in power-save mode to achieve high efficiency over the entire load current range. According to the TPS61022 datasheet, selected inductor is 1 µH and output capacitor is three 22-µF ceramic capacitors. Using MCU or a PWM generator generates a 100Hz PWM to control EN pin of TPS61022 to control output power. TPS61022 could adjust output power by adjusting PWM duty cycle and output power is not related to input voltage (battery voltage change).
4 Test Results

Figure 3 shows waveform of PWM, inductor current and output current at Vin=3.6V and duty cycle is 50%. TPS61022 adjusts output power by controlling EN pin by PWM. When EN pin is pulled to a voltage above 1.2V from 0V, the TPS61022 will be switching and when EN pin is pulled to a voltage below 0.35V from 0V, the TPS61022 is shutdown.

![Figure 3. Waveform at duty cycle is 50%](image)

Figure 4 shows the output power under different PWM duty cycle. As evident from the curve, the relationship between output power and PWM duty cycle is nonlinear. The output power is 12.5W at 100% PWM duty cycle and the output power is about 3W at 50% PWM duty cycle. Customer could adjust duty cycle of PWM to adjust output power and this will influence the taste of E-cigarette.

![Figure 4. Output power under different PWM duty cycle](image)

Figure 5 shows the efficiency at different PWM duty cycle. The graph shows the total solution efficiency is about 94% at Vin=3.6V 100% PWM duty cycle.

![Figure 5](image)
Figure 5. Efficiency at different PWM duty cycle

Figure 6 and Figure 7 show thermal pictures at different PWM duty cycle. Figure 6 shows the temperature increase of IC is about 19.6 °C at Vin=3.6V and output is 12.5W (full load). Figure 7 shows the temperature increase of IC is about 13.6 °C at Vin=3.6V and output is 3W (50% PWM duty cycle).

5 References

- [3] TPS61022 8-A boost converter with 0.5-V ultra low input voltage
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