Application Note

Fast Transient Performance Advantages in Smart Watch Applications with TPS61299

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ABSTRACT

Today smart watches are often designed with the ability to measure blood oxygen and monitor heartbeat. The application works by means of an LED that emits light onto the wrist, while the photodiode on the other side receives the reflected light, comparing the difference between the emitted light and the received light to calculate the oxygen level. Low-frequency blinking of LEDs, is challenging low-power supply designs. Especially in the moment when the LEDs light up, the load current suddenly ramps up, the output voltage to fluctuate as a result. The shorter settling time is, the shorter LED illumination time is, as a result, the more energy consumption of a portable device such as the smart bracelet is saved. In this way, the settling time of the output voltage is of the importance. Therefore, the transient performance is often an important indicator in examining power devices in smart watch.

This application note proposes a power supply solution for the TPS61299 boost converter with fast transient performance. Compared to common power solutions, smart watch with TPS61299 can extend the standby time about one day, about 6.67%.

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1 Introduction of Smart Watch Fast Transient Performance Requirements

In the smart watch application, the LED shines at a repetitive rate on the wrist, which reflected from the blood in the artery and veins gets modulated according to the oxygen content in the blood. According to the sampling theory, LED needs to flash at the frequency of 50 Hz at least to sample the signal range from 0.5 to 10 Hz relatively accurately. Since the current in LED ramps from 0 to 200 mA during hundreds of nanoseconds, the undershoot of the Output voltage is extremely large, as is shown in Figure 1-1.

If the sampling begin before output voltage return to normal value, the data accuracy is degraded extraordinarily. For example, the PSRR and SNR decreases dramatically. Hence the sampling is expected to trigger until the output voltage settles to target value, which waiting period is denoted as t_{tran} and the sampling time is t_{sample}(which is definitely customizable). This settled value is the same across all the sampling periods and the LED can be turned off after the t_{sample}. Thus the minimum t_{PWM} time can be calculated by t_{tran} plus t_{sample}. All through the t_{PWM} period, the LED current source needs to be always on, which dominates the power consumption.

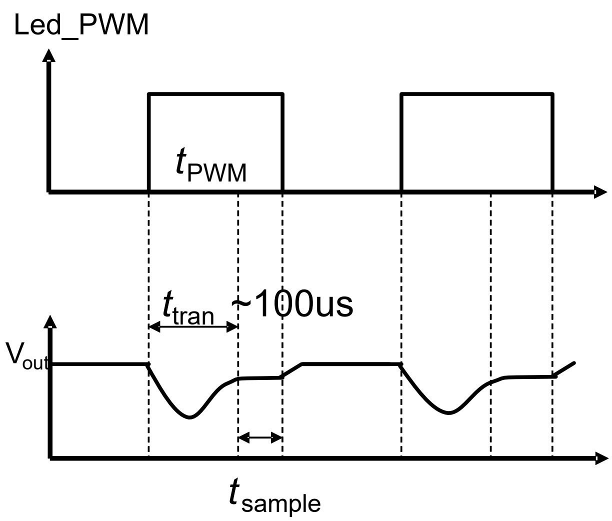

Figure 1-1. Typical Transient Response

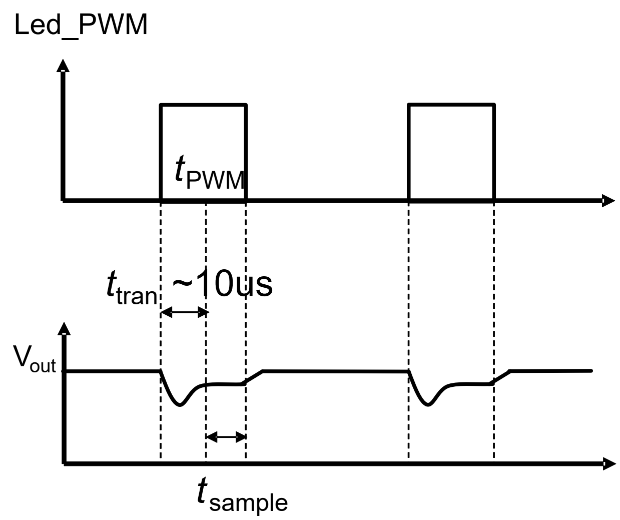

Figure 1-2. Fast Transient Response

Assuming the sample times being equal, with fast transient performance shown in Figure Figure 1-2, the t_{tran} can be reduced from 100 us to 10 us, thus the period of Led_PWM can be reduced as well, denoted as t_{PWM}. With reducing LED light time, the system reduces energy consumption and improves its efficiency.

2 TPS61299 Fast Transient Performance Introduction

2.1 Fast Transient Mode Setting

TPS61299 supports high switching frequency and obtain high bandwidth, both contributing to the utra fast transient performance. As is seen in figure Figure 2-1, pulling the Vsel pin up to Vout can easily achieve 5V output voltage under fast mode.

TPS61299 can also supports other output voltage except 5V output voltage. Refer to Table 2-1 to select target output with fast transient performance by connecting Vsel pin to ground through an resistor.

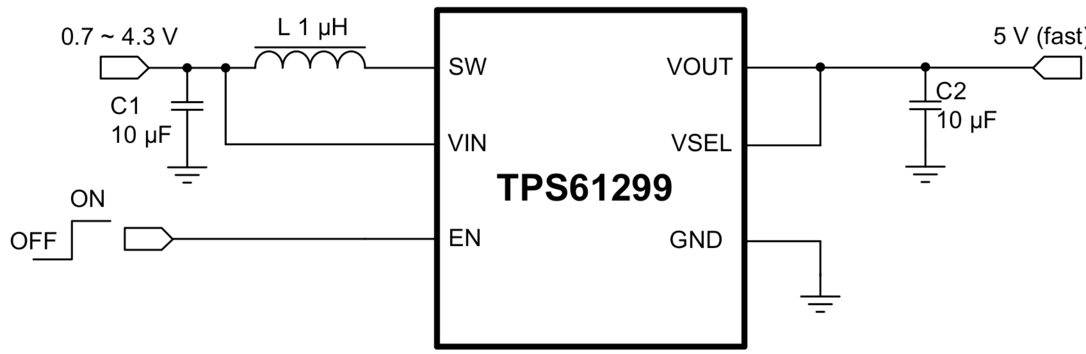

Figure 2-1. Schematic of TPS61299 Power Supply Under 5 V Vout Fast Transient Mode

Table 2-1. Vsel Pin Setting

Resistance (kΩ)	V_{OUT_REG} (V)	Resistance (kΩ)	V_{OUT_REG} (V)	Resistance (kΩ)	V_{OUT_REG} (V)	Resistance (kΩ)	V_{OUT_REG} (V)
4.75	5.5(fast)	14.7	4.5(fast)	442	5(fast)	Vout pin, 442	5(fast)

3 Standby Time Calculation

To see the benefits of fast transient performance in smart band applications visually, the following assumptions are made based on the actual market application and TPS61299 application with fast transient mode.

where:

- The LED flashing frequency is f and the LED light time is t_{pwm}
- The energy loss generated by the LED light is P_{LED} and the energy generated by system is P_{sys}.
- When flicking, the power consumption of LED is P_{AFE}
- The capacity of Li battery is E_{bat}.

The energy loss of LED is:

$$P_{AFE} = P_{LED} t_{pwm} f \quad (1)$$

The standby time of the actual market application is :

$$t = \frac{E_{bat}}{P_{sys} + P_{LED} t_{pwm} f} \quad (2)$$

Extended standby time is:

$$t_{extend} = t_2 - t_1 \quad (3)$$

t_1 is the standby time of market application and t_2 is the standby time of TPS61299 application

Table 3-1 shows the parameter of the actual market application and TPS61299 application with fast transient mode:

Table 3-1. Parameter of Smart Watch Application

Parameter	Value	Parameter	Value	Parameter	Value
t_{pwm1}	60 us	f	50Hz	P_{LED}	0.3 mW
t_{pwm2}	120 us	E_{bat}	450mAh	P_{sys}	1.159 mW

According to the parameter and equation, the energy loss of the actual market application and TPS61299 application with fast transient mode are 0.18 mW, 0.09 mW separately. The standby time of the actual market application is 14.00 days and the standby time of TPS61299 application with fast transient mode is 15.01 days, so TPS61299 application with fast transient mode can extent standby time 1.01 days.

4 Test Report Based on TPS61299 Solution

4.1 Load Transient Test for TPS61299 and TPS61099

Figure 4-1 shows the load transient waveform of TPS61299 application with fast transient mode from 0 A to 0.5 A when VIN = 3.6 V, VOUT = 5 V. Figure 4-2 shows the load transient waveform of TPS61099 from 0 A to 0.5 A when VIN = 3.6 V, VOUT = 5 V. The t_{tran} of TPS61299 application with fast transient mode and t_{tran} of TPS61099 is 8us, 86.8us separately.

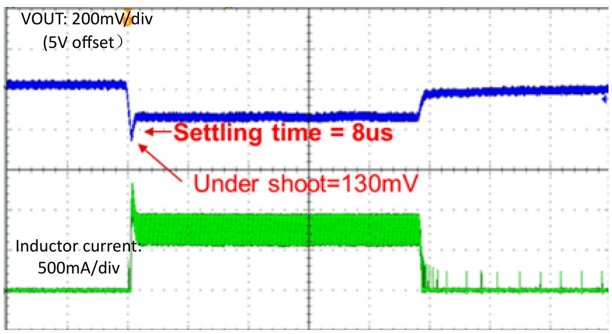

Figure 4-1. TPS61299 Transient Performance

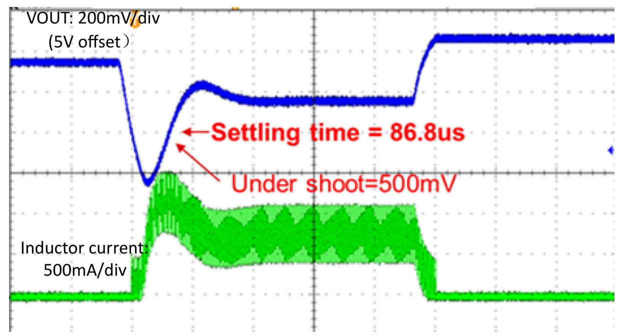

Figure 4-2. TPS61099 Transient Performance

4.2 Efficiency and Load Regulation

Figure 4-3 shows the efficiency of TPS61299 with Vout =5 V, under different input voltage. As is seen, the efficiency under 1uA ultra light load can still keep above 70% when Vin higher than 3.0 V. Especially, the efficiency when output current higher than 6mA can maintain as high as 95% (when Vin=4.3 V) , which is the same with normal mode.

Figure 4-4 shows the regulation of TPS61299 with Vout =5 V, under different input voltage.

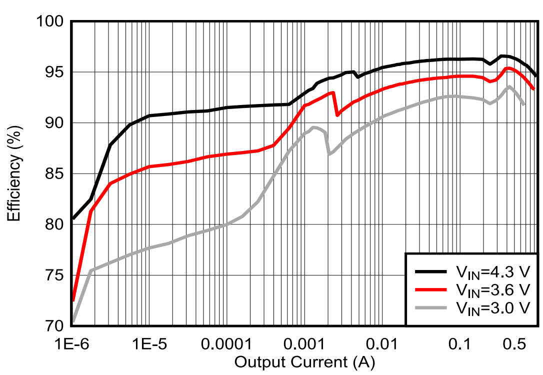

Figure 4-3. TPS61299 Efficiency ,Vout=5 V

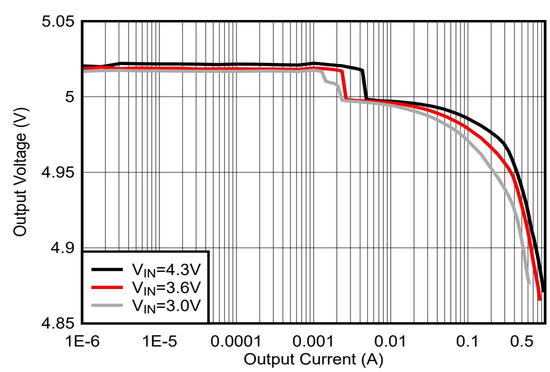

Figure 4-4. TPS61299 Load Regulation ,Vout=5V

4.3 Output Ripple Test for TPS61299 and TPS61099

Figure 4-5 through Figure 4-7 show that the output voltage ripple of TPS61099 when Iout is 0 mA, 25mA and 200mA, VIN is 3.6 V and VOUT is 5 V. Figure 4-8 through Figure 4-10 show that the output voltage ripple of TPS61299 when Iout is 0 mA, 25mA ,and 200mA, VIN is 3.6 V and VOUT is 5 V. No matter under any conditions, TPS61299 has smaller output voltage ripple than TPS61099.

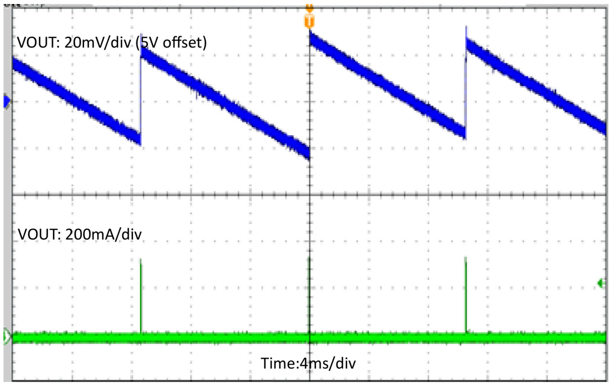

Figure 4-5. TPS61099 Vin 3.6 V, Vout 5 V, Iout 0A

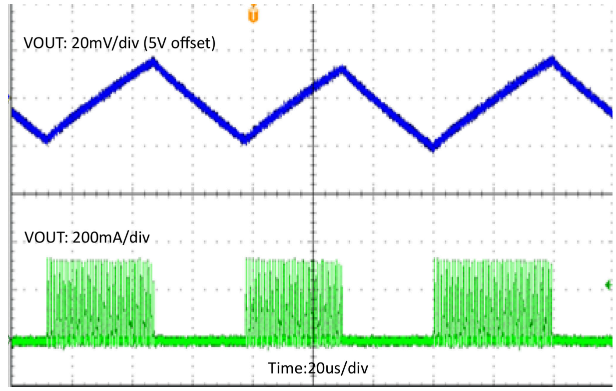

Figure 4-6. TPS61099 Vin 3.6 V, Vout 5 V, Iout 25 mA

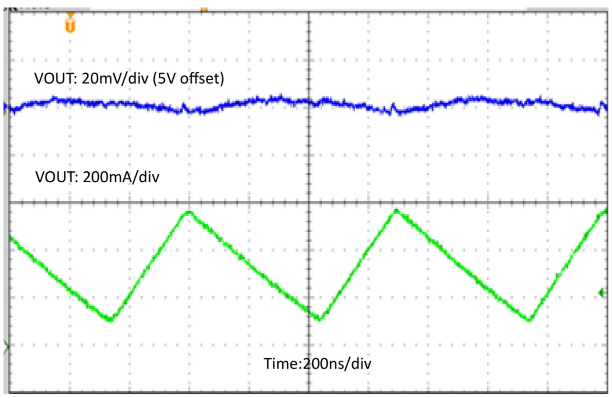

Figure 4-7. TPS61099 Vin 3.6 V ,Vout 5 V, Iout 300 mA

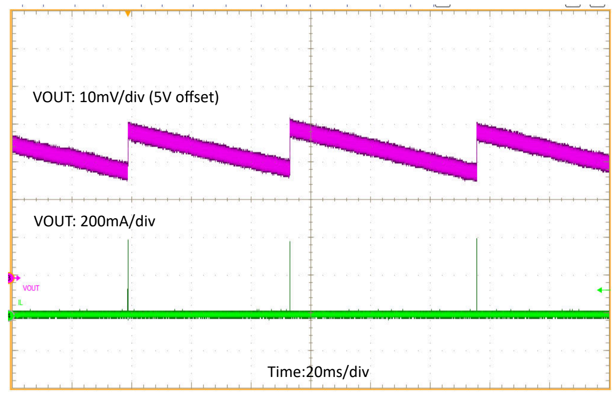

Figure 4-8. TPS61299 Vin 3.6 V ,Vout 5 V, Iout 0 A

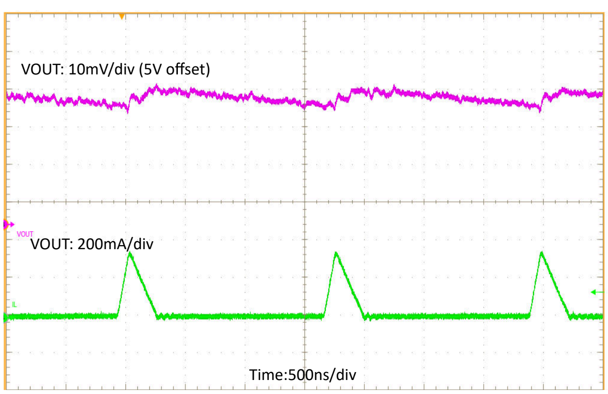

Figure 4-9. TPS61299 Vin 3.6 V, Vout 5 V, Iout 25 mA

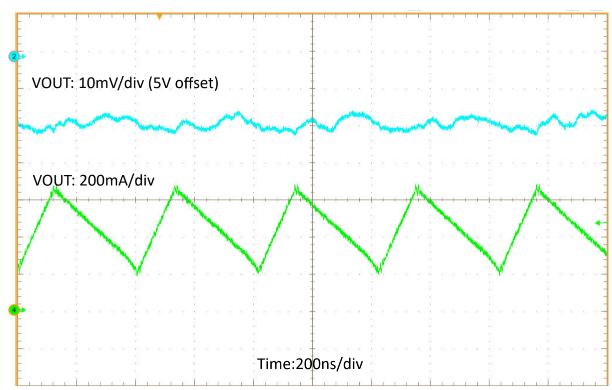

Figure 4-10. TPS61299 Vin 3.6 V, Vout 5 V, Iout 300 mA

Table 4-1 summarizes that the output voltage ripple of TPS61299 and similar product. No matter under any conditions, TPS61299 has smaller output voltage ripple than market similar product.

Table 4-1. Comparison of Output Voltage Ripple Between TPS61299 and TPS61099

Output voltage ripple	0mA	25mA	200mA
TPS61299	28 mV	7 mV	6 mV
TPS61099	52 mV	100 mV	8 mV

5 Conclusion

Using the TPS61299 boost convert system has fast transient performance that greatly reduces adjustment time, increases power system efficiency, and extends smart watch standby time. The TPS61299 is suitable for smart watch fast transient performance applications. And TPS61299 has higher efficiency and smaller output voltage ripple than market similar product.

At the same time the TPS61299 can be used in other portable product application scenarios, especially for the scenario where the load fluctuates regularly, such as periodic low-frequency luminescence or periodic low-frequency sound waves application.

6 References

1. Texas Instruments, *TPS61299, 95nA Quiescent Current, 5.5 V Boost Converter with Input Current Limit and Fast Transient Performance.* data sheet..
2. Texas Instruments, *TPS61099, Synchronous Boost Converter with Ultra-Low Quiescent Current.* data sheet.