TPS6108x: A boost converter with extreme versatility

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Introduction

The TPS61080 and TPS61081 are highly integrated boost converters that have adjustable outputs of up to 27 V with input voltages as low as 2.5 V. The difference between the two versions is the current-limit rating of the integrated power switches (typically 0.5 A and 1.3 A, respectively). The TPS6108x boost converters have a traditional current-mode-control scheme and a constant pulse-width-modulation (PWM) frequency for low-noise operation. The switching frequency can be configured to either 600 kHz for light-load efficiency or 1.2 MHz for smaller, external components. With integrated feedback compensation, internal power switches, and fast PWM switching, the 3×3-mm QFN package enables an extremely small boost converter for a wide variety of applications. An example is a 12- or 24-V industrial power rail from a 3.3- or 5-V bus. Additional features include high efficiency, an adjustable reference voltage, and redundant protection circuits—all of which make the TPS6108x ideal for boosting the 3.6-V Li-ion battery voltage used in most portable applications. The converters also support the higher voltages needed for powering thin-film-transistor (TFT) LCDs, OLED displays, WLED backlights, or camera flashlights.

Figure 1. Typical application for a 12-V boosted output

Figure 2. Efficiency with V_{IN} = 3.6 V

Powering displays

Figure 1 shows the converter in a typical boost configuration that provides a regulated output voltage. When up to 20 V and 100 mA are required to drive each column of a passive-matrix OLED (PMOLED), the 1.3-A switch rating makes the TPS61081 the best choice. When less than 10 V and only tens of milliamps per column for the active-matrix OLED (AMOLED) are provided, the 0.5-A switch rating of the TPS61080 may be more appropriate. In either case,
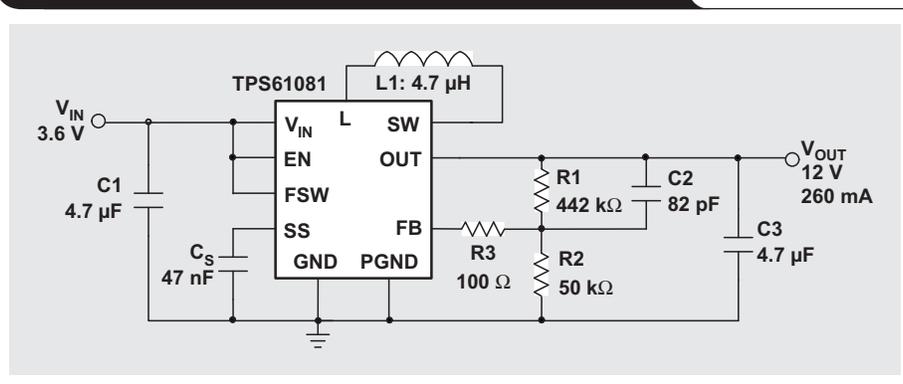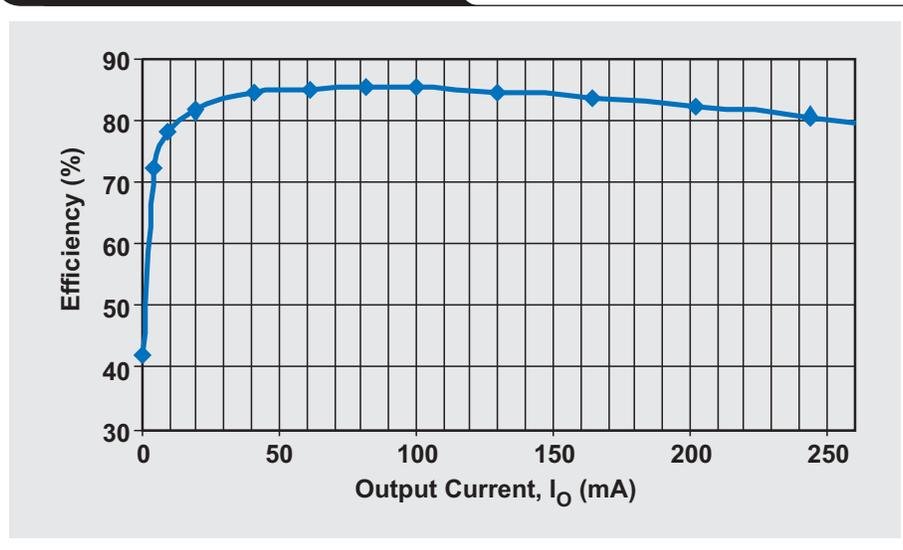
the low-$R_{DS(on)}$ internal switches and the choice of switching frequency provide optimal supply efficiency. Figure 2 shows efficiency data for a 12-V output when a Li-ion battery with a typical 3.6-V source voltage is used.

To support the gates of the TFT drivers for active-matrix LCDs or OLED displays, the high-voltage rail must be capable of fast transients. The TPS61080 has current-mode control and optimized internal compensation; and it can operate at 1.2 MHz with a 4.7-µH inductor, making it ideal

for fast-transient response. Figure 3 shows the transient response of the TPS61080, which was configured as shown in Figure 1 except for an additional 4.7-µF output capacitor.

WLED-display backlight driver

As shown in Figure 4, most boost converters can be used to power WLEDs if the voltage-feedback network is replaced with the WLED strings and a series current-sense resistor, R3. The TPS6108x can be used to drive several series WLEDs in parallel for backlighting larger displays.

The voltage across the current-sense resistor is fed back to provide regulation. Traditional boost converters use 1.2-V feedback voltages; therefore, the power loss due to R3 is $P_{LOST} = I_{WLED}^2 \times R3 = 1.2\ V \times I_{WLED}$. The TPS6108x converters have an SS pin that is used to provide variable soft startup for boosted voltage-regulation applications. The SS pin can also be used to lower the FB-pin reference voltage and to reduce sense-resistor power loss in a WLED current-regulation application. Simply connecting a resistor, R1, from the SS pin to GND will lower the FB-pin reference voltage. The reference voltage equates to the resistance of R1 times the SS-pin bias current ($I_{SS} = 5\ µA$ typical), resulting in the WLED current calculation:
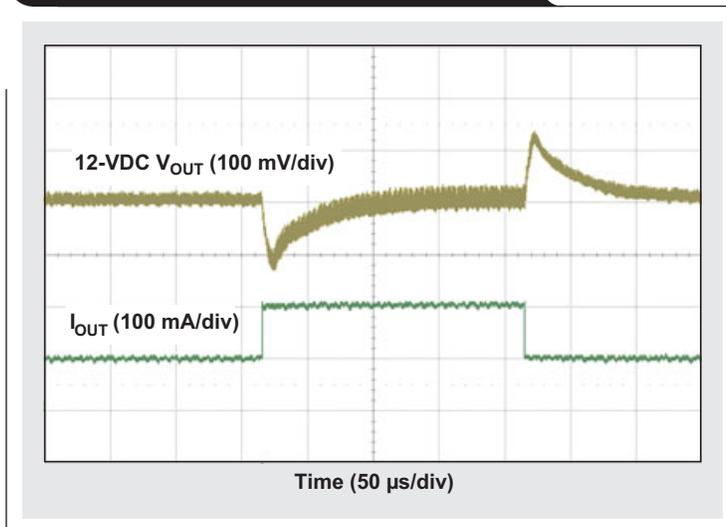
$$I_{WLED} = \frac{I_{SS} \times R1}{R3}$$

A second resistor, R2, in series with the FET and Q1 and in parallel with R1 provides analog dimming by lowering the regulated FB-pin voltage across the sense resistor.
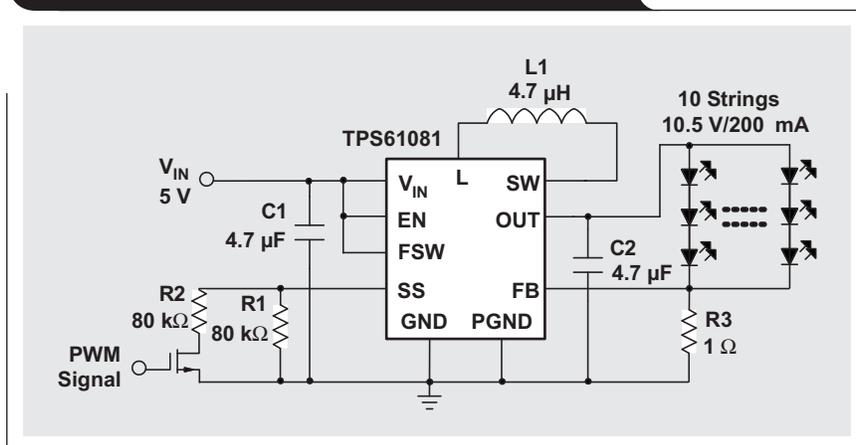
Protection

Two of the most common boost-converter design challenges are how to handle the conduction path from input to output and how to prevent overvoltage. The conduction path creates three problems: leakage voltage under shutdown,

inrush current during startup, and excessive short-circuit current. To address these issues, the TPS6108x has an integrated isolation switch that opens during shut-down mode to prevent a possible current path. This isolation switch and the soft-start circuitry also control inrush current during startup to prevent the input supply from drooping and possibly causing system instability. The TPS6108x keeps the isolation FET off until the EN pin is pulled high and V_{IN} rises above the undervoltage-lockout threshold. The Vgs of the isolation FET is clamped so that its high on-resistance limits the inrush current related to charging the output capacitor to V_{IN}. When the output capacitor reaches V_{IN}, the IC fully turns on the low $R_{DS(on)}$ isolation FET and activates soft start as programmed by the soft-start capacitor on the SS pin. In the event that V_{OUT} stays below V_{IN} for more than 2 ms, indicating a short-circuit condition, the isolation

Figure 3. Transient response of TPS61080

12-VDC V_{OUT} (100 mV/div)

I_{OUT} (100 mA/div)

Time (50 µs/div)

Figure 4. TPS61081 WLED backlight driver circuit

FET turns off and the IC will not restart until the EN pin toggles or V_{IN} goes through power-on reset (POR).

The TPS6108x also has pulse-by-pulse overcurrent limiting, which turns off the power switch once the inductor current reaches a preset value (0.7 A for the TPS61080 and 1.6 A for the TPS61081). The power switch turns back on at the beginning of the next switch cycle. When the inductor current stays above the short-circuit current limit for more than 13 µs or the V_{OUT}-pin voltage goes 1.4 V below V_{IN}, the IC assumes that there is a short-circuit condition and turns off the isolation FET. After 57 ms, the IC attempts to restart. If a momentary short is cleared, the output returns to its regulation voltage and switches normally. For a permanent short, the isolation FET turns off again and waits for POR or EN-pin toggling. Although the isolation switch has a low $R_{DS(on)}$ for minimum power loss, shorting the V_{IN} and L pins can bypass the switch and further enhance the efficiency.

When the TPS61081 is configured for regulated current output as shown in Figure 4, the output voltage could run away if the output impedance becomes too high (i.e., if a WLED burns out or the load is disconnected). To prevent the power switch from exceeding its maximum voltage rating, the overvoltage-protection (OVP) circuit turns off the power switch when the output voltage exceeds the OVP threshold. When the output voltage falls below the OVP threshold, the converter resumes normal PWM operation.

Conclusion

This extremely versatile, integrated-FET boost converter is ideal for industrial, medical, telecom, and consumer applications that require boosted voltages. Features such as variable-reference voltage and multiple-protection circuitry make the TPS6108x also well-suited for powering LCDs and OLED displays.

Reference

For more information related to this article, you can download an Acrobat Reader file at www-s.ti.com/sc/techlit/ *litnumber* and replace *"litnumber"* with the **TI Lit. #** for the materials listed below.

Document Title   **TI Lit. #**

1. "High Voltage DC/DC Boost Converter with 0.5-A/1.3-A Integrated Switch," TPS61080/1 Datasheet slvs644

Related Web sites

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