

## Tiny Package, High Performance, Constant Current Switching Regulator for White LED

### General Description

The uP6008 is a compact high-efficiency step-up converter with integrated switch specifically designed to drive up to seven white LEDs in series. Series connection of the LEDs provides identical current resulting in uniform brightness. Fixed 1.0 MHz operation allows smallest output ripple and external component size. With high conversion efficiency and small package, the uP6008 is suitable for portable devices which PCB area is especially concerned.

The uP6008 features over-voltage protection against open-LED situation. A single pin provides shutdown and accurate LED dimming control. Other features includes internal soft start, internal compensation, over-current protection, and over temperature protection.

The uP6008 is available in SOT23 - 6L package.

### Ordering Information

Order Number	Package Type	Remark
uP6008PMA6	SOT23 -6L	
uP6008QMA6		

Note:

- (1) Please check the sample/production availability with uPI representatives.
- (2) uPI products are compatible with the current IPC/JEDEC J-STD-020 requirements. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

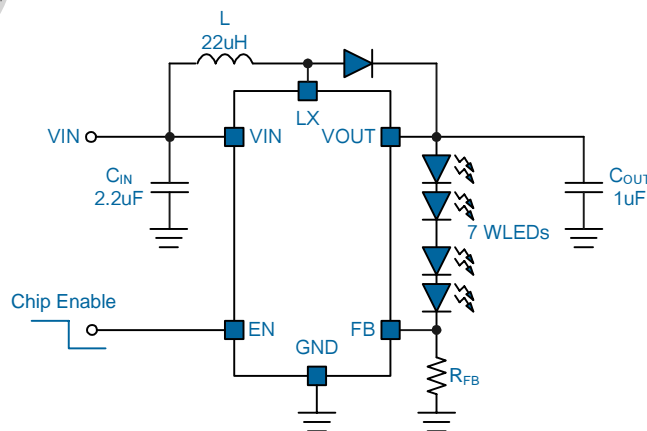
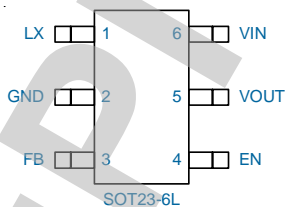
### Features

- Drive Up to Seven White LEDs from 3V Supply
  - Wide VIN Range from 2.5V to 6V
  - Internal Soft-Start
- One Pin Shutdown and Dimming Control
  - Wide Range for PWM Dimming (100Hz to 200kHz)
  - Under Voltage Protection
- Over-Temperature and Over-Voltage Protection
- Integrated 2A, 0.2Ω Switch
- Internal Compensation
- Small SOT23-6L Package
- RoHS Compliant and Halogen Free

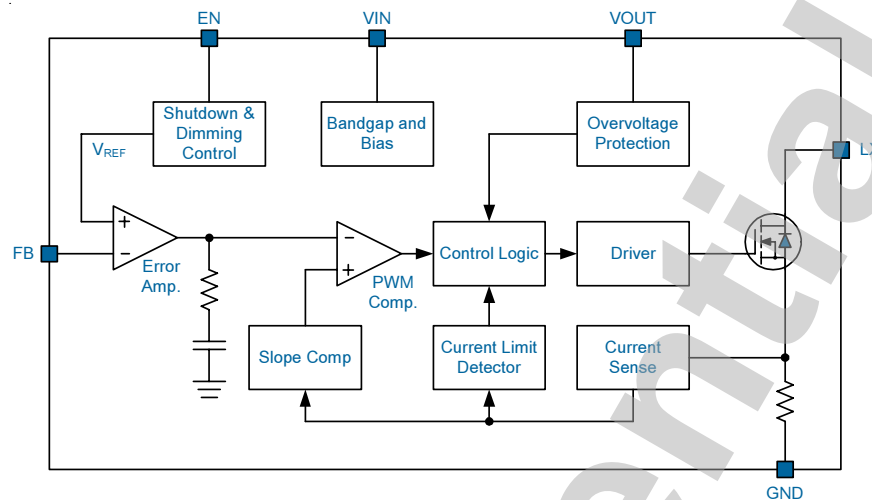
### Applications

- White LED Supply for Backlight Displays
  - Cellular Phones
  - PDSs, Handheld Computers
  - Digital Cameras
  - MP3 Players
  - GPS Receivers
  - Camcorders

### Pin Configuration & Typical Application Circuit



Functional Block Diagram



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	LX	<b>Internal Switch Output.</b> The pin is the drain of internal NMOSFET. Connect this pin to the boost inductor and anode of external Schottky diode.
2	GND	<b>Ground.</b> Ties the pin directly to the cathode terminal of $C_{IN}$ and $C_{OUT}$ and ground plane with the lowest impedance. All small-signal and feedback components should connect to this pin.
3	FB	<b>Current Feedback.</b> This pin is the inverting-input of error amplifier. The LED current is sensed through a series resistor and regulated to internal reference voltage.
4	EN	<b>Shutdown and Dimming Control.</b> Pulling this pin low shuts down the converter. This pin receives pluses for LED dimming control (see the related section.)
5	VOUT	<b>Output Voltage.</b> Connect this pin directly to the output voltage. This pin is monitored for output overvoltage protection against open-LED. A minimum 1uF X5R or X7R ceramic capacitor is required.
6	VIN	<b>Power Supply Input.</b> Input voltage that supplies current to the output voltage and powers the internal control circuit. Bypass input voltage with a minimum 2.2uF X5R or X7R ceramic capacitor.

---

**Functional Description**

The uP6008 is a compact high-efficiency step-up converter with integrated switch specifically designed to drive up to 7 WLEDs in series. Series connection of the LEDs provides identical LED current resulting in uniform brightness. Fixed 1.0MHz operation allows smallest output ripple and external component size. With high conversion efficiency and small package, the uP6008 is suitable for portable devices where PCB area is especially concerned.

**Power on Reset**

The uP6008 continuously monitor supply input voltage at VIN pin for power on reset (POR). Once the rising POR threshold is exceeded, the uP6008 sets itself to active state and is ready to accept chip enable command. The POR threshold is typically 2.2V at  $V_{IN}$  rising with 0.1V hysteresis.

**Enable/Disable**

Pulling the EN pin higher than 1.4V enables the device and initiate its soft start cycle. Pulling the EN pin lower than 0.4V disables the device and reduces its shutdown current less than 1uA typically. When the EN pin pulls low, the uP6008 does not shut down immediately but reduces the LED current gradually.

**Soft Start**

The uP6008 limits the in-rush current at start-up by increasing the current limit. This prevents unwanted shutdown otherwise may be triggered by voltage drop due to large inrush current.

**LED Current Regulation**

The uP6008 operates in a constant-frequency, slope-compensated peak-current-mode control to regulate the LED current. The LED current is sensed at FB pin by a current sensing resistor ( $R_{FB}$ ):  $V_{FB} = R_{FB} \times I_{LED}$ . The error amplifier compares the feedback voltage with internal 0.3V reference and compensates the error signal to get current command level.

The internal NMOSFET turns on at the beginning of each switching cycle and lets the inductor current ramp up linearly. The NMOSFET turns off when the inductor current reaches the current command level. The uP6008 modulates on-time of NMOSFET by changing the current command to regulate the LED current.

**Dimming Control**

The uP6008 receives a PWM signal at EN pin for LED brightness control. The PWM signal is filtered by internal low pass filter to get a reference voltage that is proportional to the duty cycle of the PWM signal. The uP6008 does not turn off as the EN pin is pulled high or low as shown in the Typical Operation Characteristics section. This eliminates inrush current and audio noise that may occur in conventional PWM dimming control.

The PWM frequency range from 100Hz to 200kHz is acceptable and yields linear brightness control.

**Current Limit Function**

The uP6008 features cycle-by-cycle current to prevent the device from damage due to over current that might be a result of abnormal operation.

The uP6008 turns off the NMOSFET when its current exceeds the current limit of 2A minimum, preventing the inductor current from continuously ramping up. The NMOSFET is turned on at the next switching cycle. This minimizes the power dissipation and component stresses under over load and short-circuit conditions.

**Over Voltage Protection**

The over voltage protection prevents damage to uP6008 during high output voltage conditions. When the output voltage is higher than the Threshold Limit, the converter stops switching and the output voltage decays. Switching would be turned on again when the voltage of the OVP pin drops below the lower hysteresis limit.

**Over Temperature Protection**

The excessive internal dissipation of thermal protection will malfunction uP6008. The junction over-temperature threshold is 160°C with 30°C of temperature hysteresis. The output voltage resumes when the over temperature fault condition is removed.

**Absolute Maximum Rating**

(Note 1)

Supply Input Voltage, $V_{IN}$	-----	-0.3V to +6.5V
LX, VOUT Pin Voltage	-----	-0.3V to +30V
Other Pins	-----	-0.3V to +6V
Storage Temperature Range	-----	-65°C to +150°C
Junction Temperature	-----	150°C
Lead Temperature (Soldering, 10 sec)	-----	260°C
ESD Rating (Note 2)		
HBM (Human Body Mode)	-----	2kV
MM (Machine Mode)	-----	200V

**Thermal Information**

Package Thermal Resistance (Note 3)		
SOT23 - 6L $\theta_{JA}$	-----	250°C/W
SOT23 - 6L $\theta_{JC}$	-----	100°C/W
Power Dissipation, $P_D$ @ $T_A = 25^\circ\text{C}$		
SOT23 - 6L	-----	0.4W

**Recommended Operation Conditions**

(Note 4)

Operating Junction Temperature Range	-----	-40°C to +125°C
Operating Ambient Temperature Range	-----	-40°C to +85°C
Supply Input Voltage, $V_{IN}$	-----	+2.8V to +5.5V

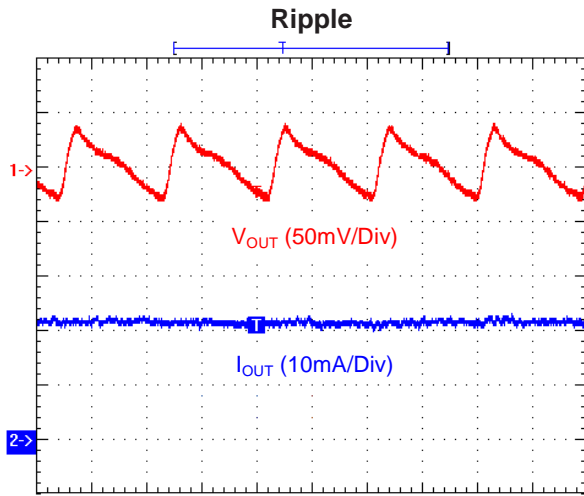
- Note 1.** Stresses listed as the above *Absolute Maximum Ratings* may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.
- Note 2.** Devices are ESD sensitive. Handling precaution recommended.
- Note 3.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ\text{C}$  on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.
- Note 4.** The device is not guaranteed to function outside its operating conditions.

**Electrical Characteristics**

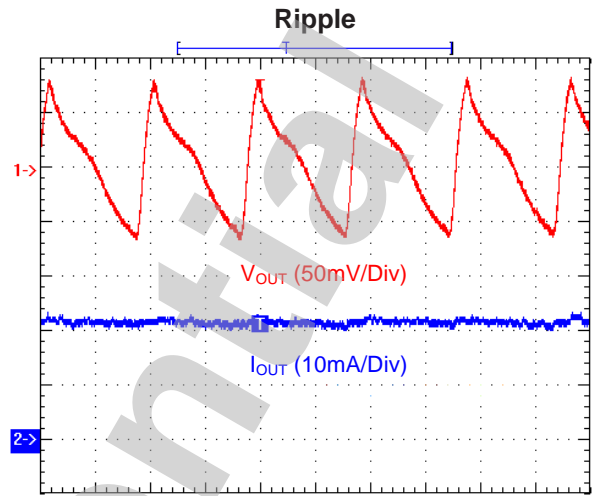
( $V_{IN} = 3.7V$ ,  $C_{IN} = 2.2\mu F$ ,  $C_{OUT} = 1\mu F$ ,  $I_{OUT} = 20mA$ ,  $L = 22\mu H$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
<b>Supply Current</b>						
Supply Voltage Range	$V_{IN}$		2.5	--	6.0	V
Power On Reset Threshold	$V_{IN}$	$V_{IN}$ Rising	2.0	2.2	2.45	V
Power On Reset Hysteresis	$\Delta V_{IN}$		--	0.1	--	V
Quiescent Current	$I_Q$	$V_{EN} = 5V$ , $V_{FB} = 1.5V$ , $I_{OUT} = 0mA$ , (No Switching)	--	200	300	$\mu A$
Supply Current	$I_{IN}$	FB = 0V, Switching	--	1	2	mA
Shutdown Current	$I_{SHDN}$	$V_{EN} = 0V$	--	1	4	$\mu A$
<b>Reference</b>						
Reference Voltage	$V_{FB}$	uP6008P	0.196	0.2	0.204	V
		uP6008Q	0.294	0.3	0.306	
Line Regulation		$V_{IN} = 3.0V \sim 4.3V$	--	1	--	%
Dimming Control Accuracy		PWM duty cycle > 20% at 20kHz	--	5	--	%
Minimum Dimming Duty			5	--	100	%
<b>Oscillator</b>						
Switching Frequency Range	$f_{OSC}$		0.75	1	1.25	MHz
Maximum Duty Cycle			90	92	--	%
<b>Power Switch and Diode</b>						
$R_{DS(ON)}$ Switch	$R_{DS(ON)}$	$I_{LX} = 100mA$	--	0.2	--	$\Omega$
<b>Logic Input</b>						
EN Logic Low Threshold	$V_{IL}$	$V_{IN} = 2.8V$ to 6V, Shutdown	--	--	0.4	V
EN Logic High Threshold	$V_{IH}$	$V_{IN} = 2.8V$ to 6V, Enable	1.4	--	--	V
EN Sink Current	$I_{IH}$		--	1	--	$\mu A$
PWM Frequency for Dimming			0.1	--	200	kHz
Shutdown Delay			--	20	--	ms
<b>Protection</b>						
Over Voltage Protection Level			25	27	29	V
Current Limit Level	$I_{LX}$		2	--	--	A
Thermal Shutdown Temperature	$T_{SHDN}$	By design	--	160	--	$^\circ C$
Thermal Shutdown Hysteresis	$\Delta T_{SHDN}$	By design	--	30	--	$^\circ C$

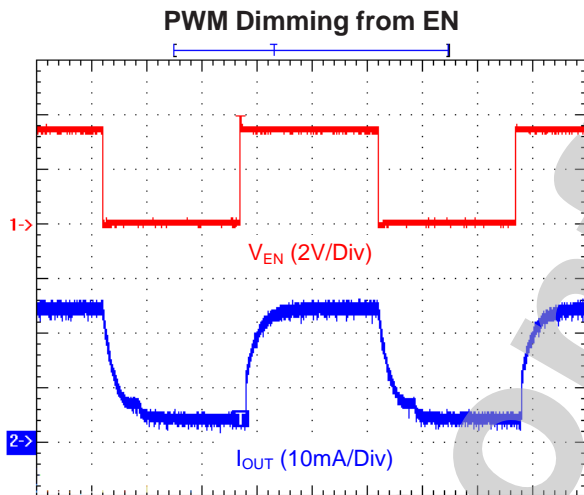
Typical Operation Characteristics



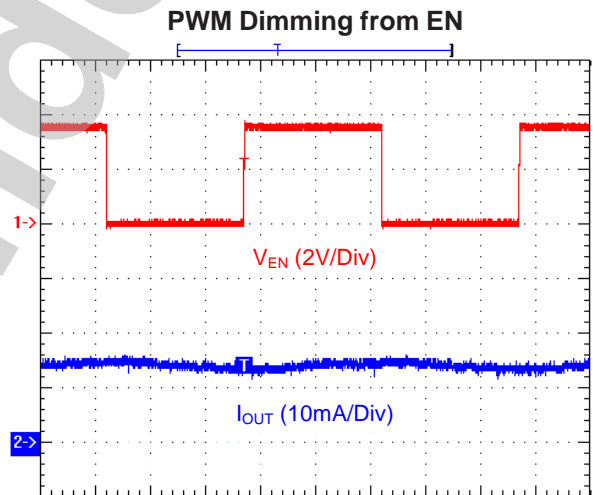
500ns/Div  
 $V_{IN} = 3.7V, I_{OUT} = 20mA, C_{OUT} = 1\mu F$



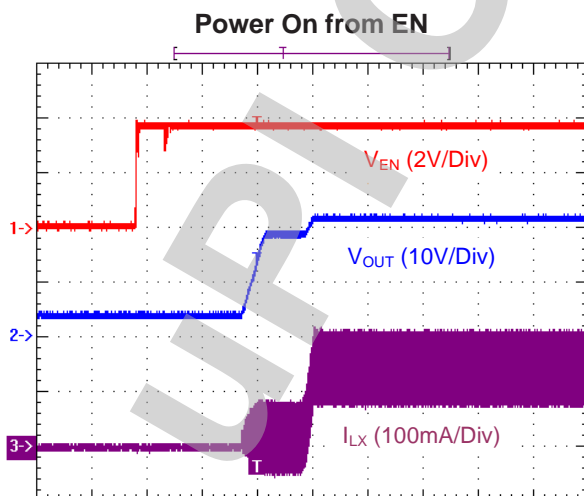
500ns/Div  
 $V_{IN} = 3.7V, I_{OUT} = 20mA, C_{OUT} = 0.22\mu F$



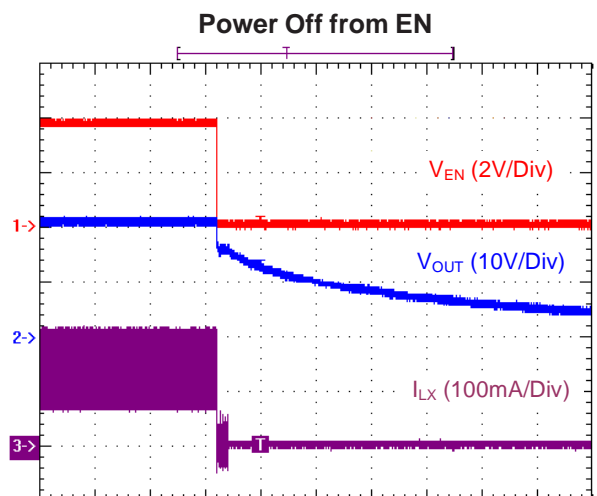
1ms/Div  
 $V_{IN} = 3.7V, I_{OUT} = 20mA, F_{DIM} = 200Hz$



10us/Div  
 $V_{IN} = 3.7V, I_{OUT} = 20mA, F_{DIM} = 20kHz$

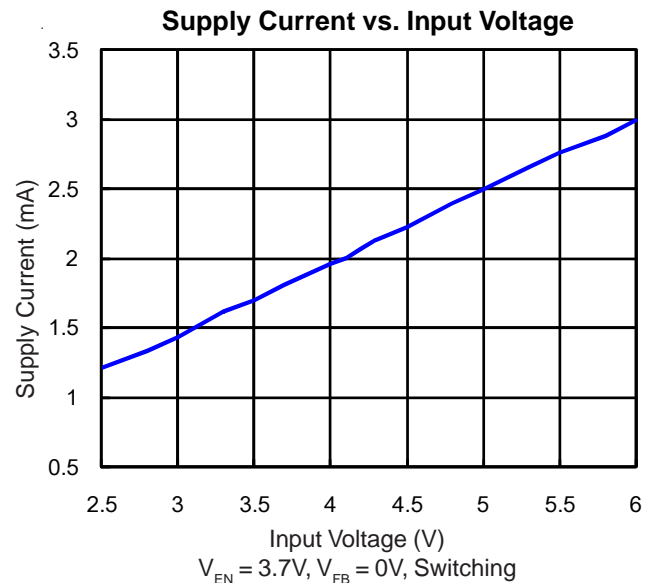
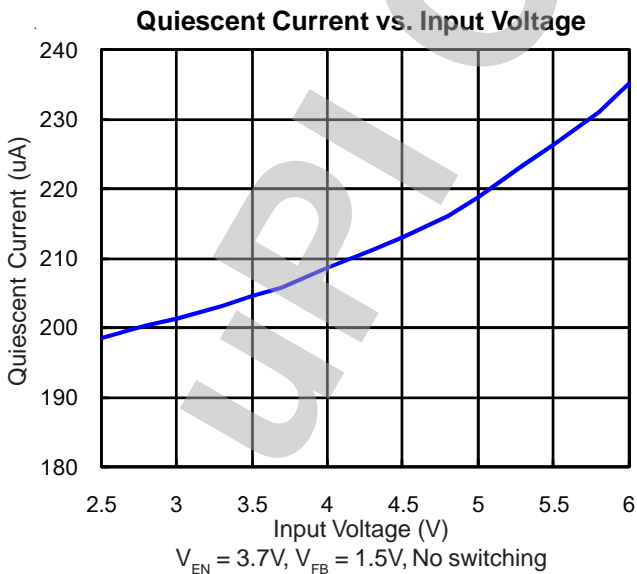
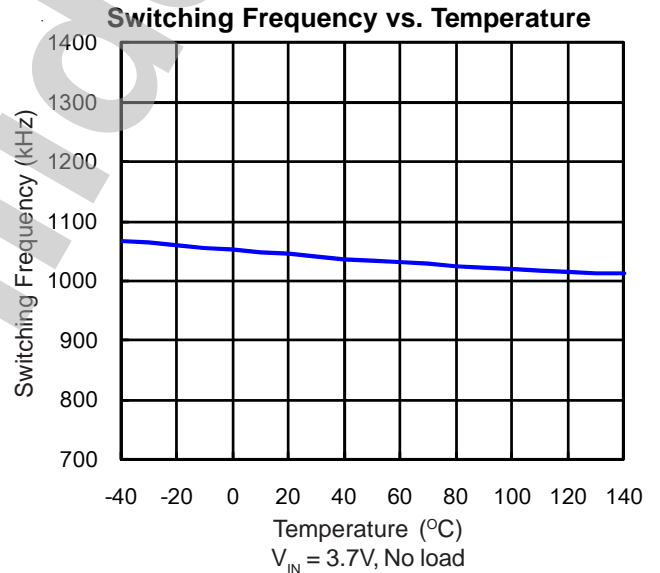
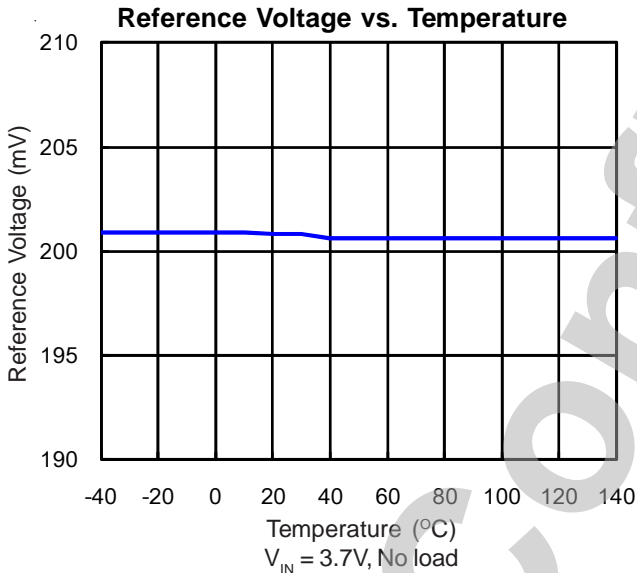
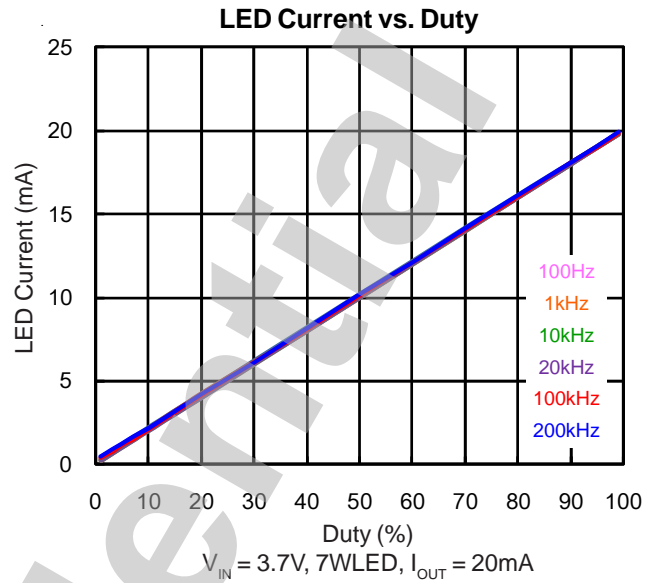
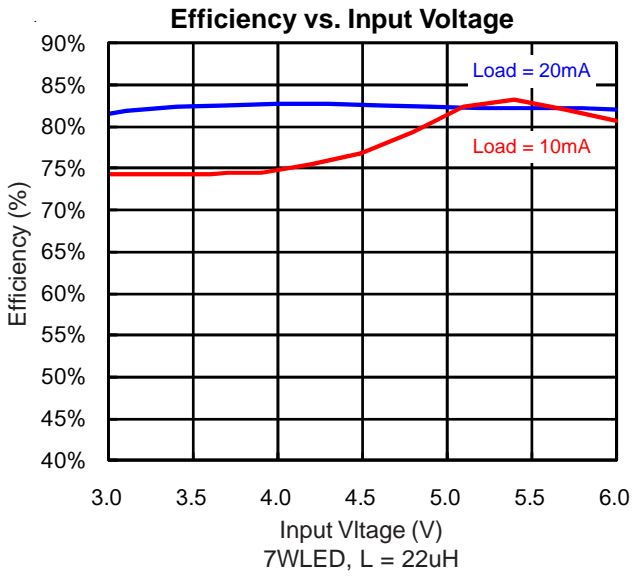


2ms/Div  
 $V_{IN} = 3.7V, I_{OUT} = 20mA$



100ms/Div  
 $V_{IN} = 3.7V, I_{OUT} = 20mA$

Typical Operation Characteristics



Application Information

Component Selection

External component selection begins with inductor value selection based on the considerations of the output voltage, output current, and the maximum/minimum input voltages. Catch diode and input/output capacitors can be selected according to the inductor value L.

Inductor Selection

Inductor selection should consider the inductor value, rated current, DCR, size, core material, and cost. The inductor value is selected based on the consideration of inductor ripple current. The recommended value of inductor for 10 WLEDs applications is from 10uH to 22uH. The inductor should have low core loss at 1MHz and low DCR for better efficiency. The inductor saturation current rating should be considered to cover the inductor peak current.

Maximum Output Current vs. Output Voltage

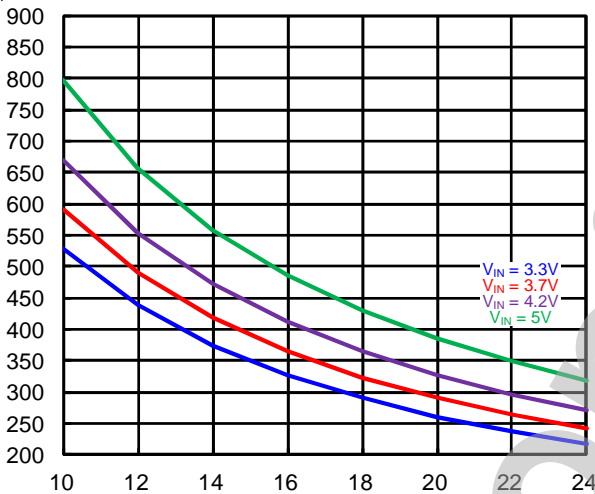


Figure 2. Maximum Output Current vs. Output Voltage

$$I_{OUT(MAX)} = (1 - D) \times \eta \times \left( I_{LX} - \frac{1}{2} \times \frac{V_{IN}}{F_{OSC} \times L} \times D \right)$$

Calculation conditions:

L = 10uH, F<sub>OSC</sub> = 1MHz, η = 0.85, I<sub>LX</sub> = 2A

Multi-strings Application

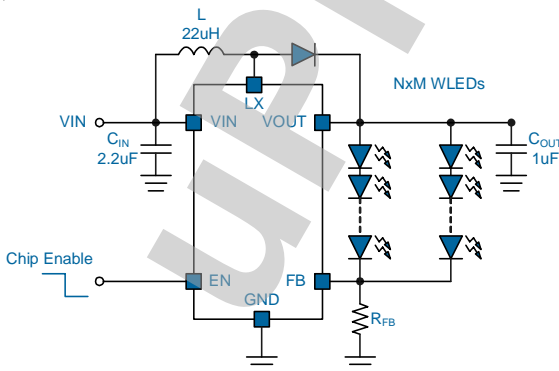


Figure 3. Application for Driving n x m WLEDs

Please consider the Maximum Output Current vs. Output Voltage relationship when used for n x m WLEDs application.

Layout Consideration

For best performance of the uP6008, the following guidelines must be strictly followed.

- Input and output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
- The GND should be connected to a strong ground plane for heat sinking and noise protection.
- Keep the main current traces as short and wide as possible.
- LX node of DC-DC converter is with high frequency voltage swing. It should be kept at a small area.
- Place the feedback components as close as possible to the IC and keep away from the noisy devices.

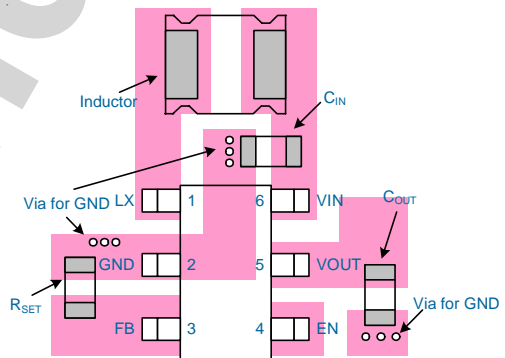
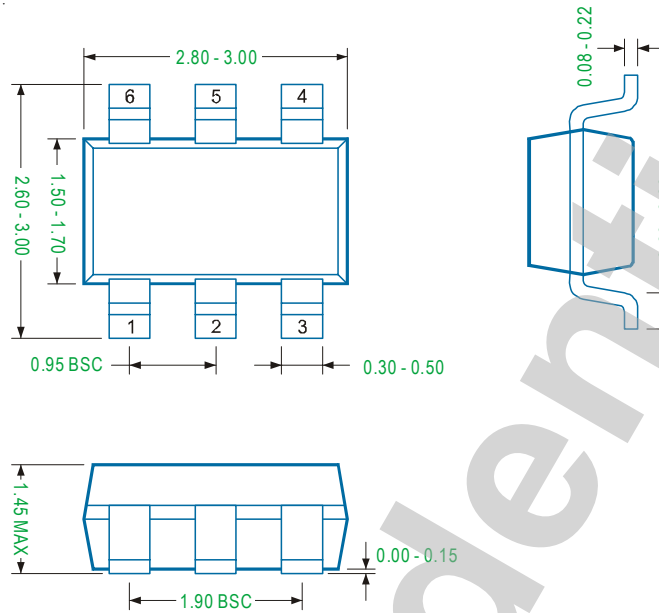


Figure 1. SOT23 - 6L Layout Reference



SOT23 - 6L



Note

1. Package Outline Unit Description:

BSC: Basic. Represents theoretical exact dimension or dimension target

MIN: Minimum dimension specified.

MAX: Maximum dimension specified.

REF: Reference. Represents dimension for reference use only. This value is not a device specification.

TYP: Typical. Provided as a general value. This value is not a device specification.

2. Dimensions in Millimeters.

3. Drawing not to scale.

4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.

### Important Notice

uPI and its subsidiaries reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

uPI products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgment. However, no responsibility is assumed by uPI or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of uPI or its subsidiaries.

COPYRIGHT (c) 2013, UPI SEMICONDUCTOR CORP.

#### **uPI Semiconductor Corp.**

Headquarter

9F., No. 5, Taiyuan 1st St. Zhubei City,  
Hsinchu Taiwan, R.O.C.

TEL : 886.3.560.1666 FAX : 886.3.560.1888

Sales Branch Office

12F-5, No. 408, Ruiguang Rd. Neihu District,  
Taipei Taiwan, R.O.C.

TEL : 886.2.8751.2062 FAX : 886.2.8751.5064