

### General Description

LA8303 is a voltage mode, step-down LED driver that is designed to meet maximum 2A constant current for high power LED application, and utilizes PWM control scheme that switches with 300KHz fixed frequency.

The input voltage range of LA8303 is from 3.6V to 23V. It is suitable for series-parallel 1W, 3W, or 5W high power LED application due to the high operation voltage and output capability. At 12V<sub>IN</sub>, this device can drive up to 15pcs (3S-5P) 1W LEDs. The 0.21V low feedback voltage can reduce the power dissipation of the constant current setting resistor, and improve the conversion efficiency.

This device provides excellent regulation during line or load transient. Other features of external ON/OFF control, current limit, thermal shutdown protection, and short circuit protection are also included. It can also operate with a maximum duty cycle of 100% for use in low drop-out conditions. The package is available in standard SOP-8.

### Ordering Information

**LA8303 1 2 3 4**

- 1** (Package Type) => J: SOP
- 2** (Number of Pins) => G: 8pin
- 3** (Output Voltage) => Blank: Adjustable
- 4** (Special Feature) => Blank: N/A

**Available Part Number**

LA8303JG

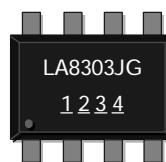
### Features

- | Up to 96% Efficiency
- | 0.21V Low Feedback Voltage
- | 3.6V to 23V Input Voltage Range
- | Driving up to 15 LEDs (1W 3S-5P) at 12V<sub>IN</sub>
- | 300KHz Oscillation Frequency
- | Continuous 2A Output Capability
- | 100% Duty Cycle
- | 3mA Low Supply Current
- | 1uA Low Shutdown Current
- | PWM or Analog Dimming Control
- | Built-in Low R<sub>DS(ON)</sub> Power MOSFET
- | No External Compensation Required
- | Adjustable Current Limit
- | Short Circuit and Thermal Protection
- | SOP-8 Package
- | Meet RoHS Standard

### Applications

- | High Power LED Driver
- | Backlight Applications
- | General Lighting Solutions
- | Constant Current Source

### Marking Information



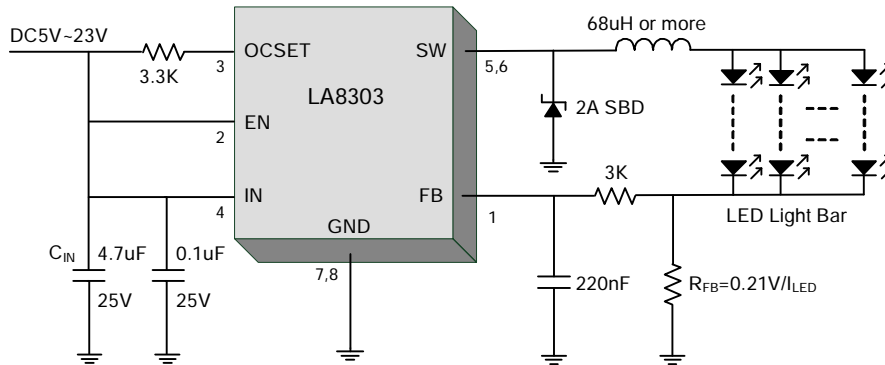
**1 2** (Date Code)

For date code rule, please contact our sales representative directly.

**3 4** (Internal Code)

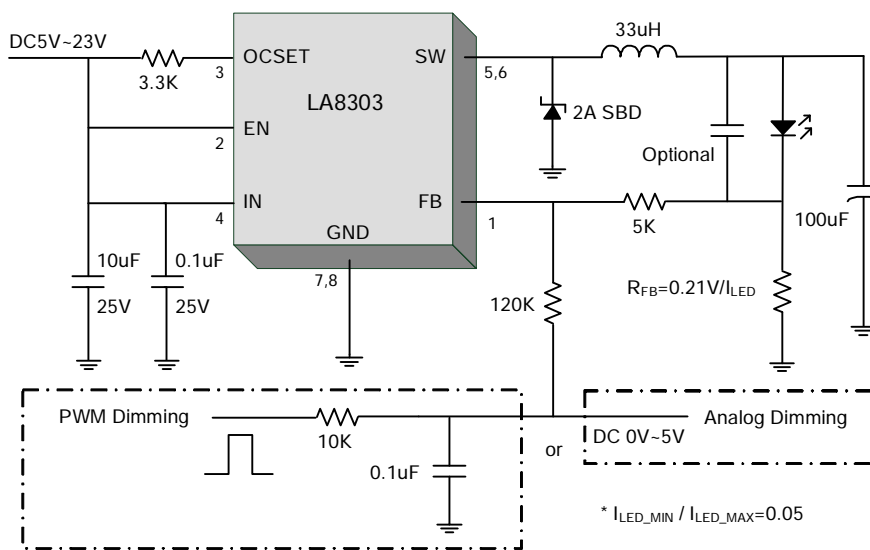
## Typical Application

### LED Light Bar Application ; Maximum 2A LED Current



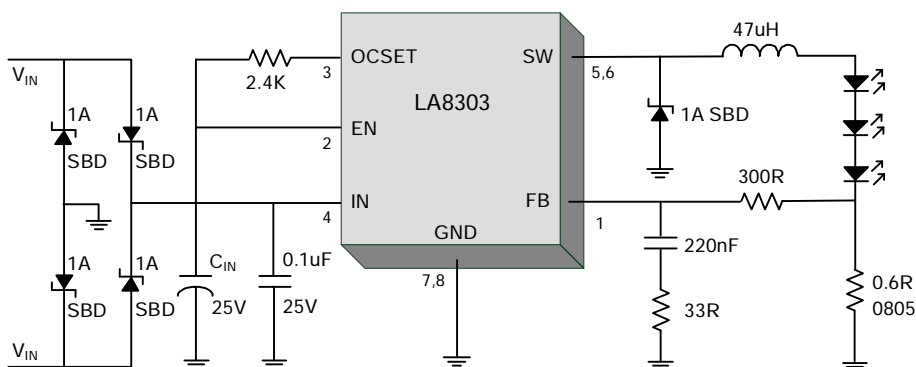
- \*  $C_{IN}$  up to 10uF or more for Hot-Plugging application
- \* Power Dissipation on  $R_{FB}$  is  $0.21V \times I_{LED}$

### High Power LED Application with Dimming Control



\*  $I_{LED\_MIN} / I_{LED\_MAX} = 0.05$

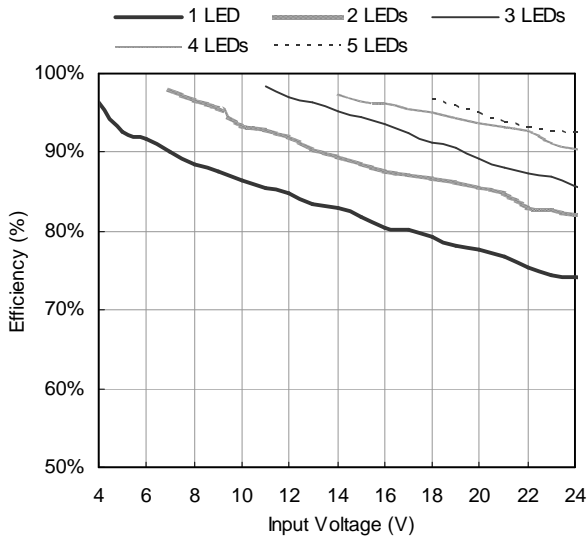
### MR-16 1Wx3 Application ; 350mA Constant LED Current



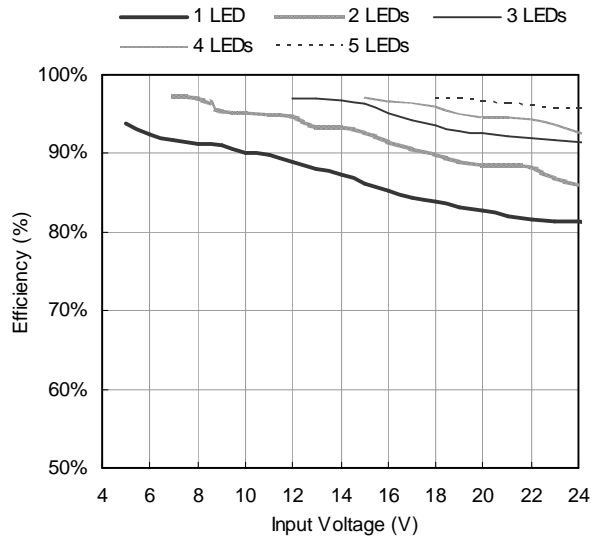
\* Recommended  $C_{IN}$  : 330uF or more

**Efficiency Curve**

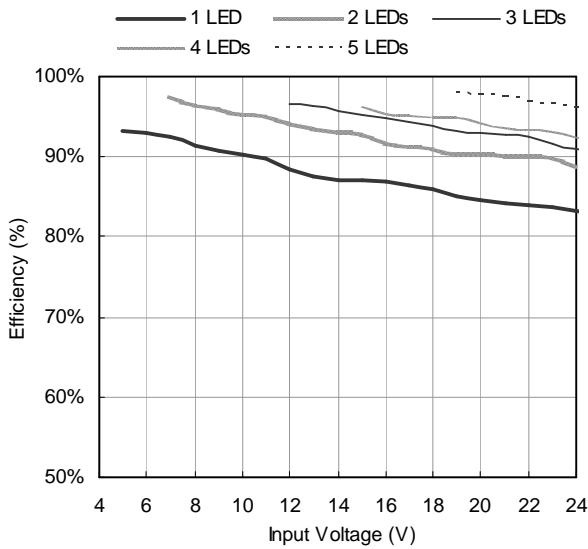
$I_{LED}=350mA$



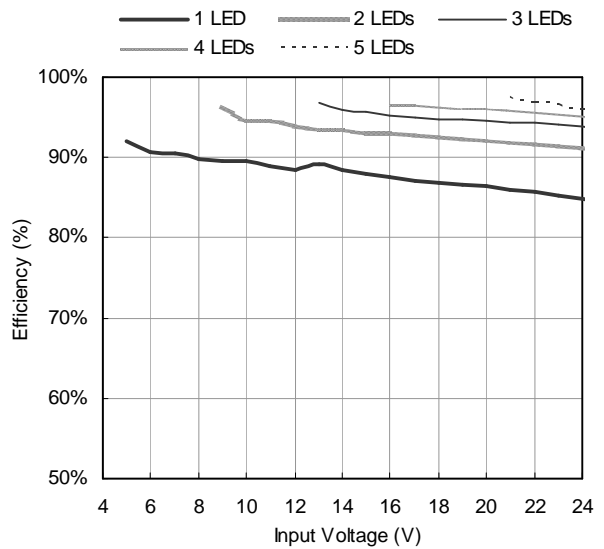
$I_{LED}=700mA$



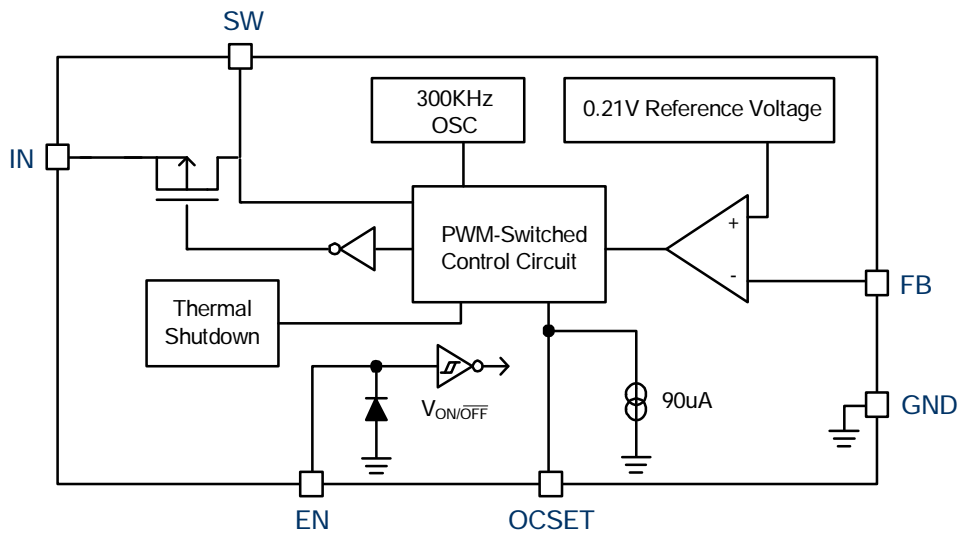
$I_{LED}=1A$



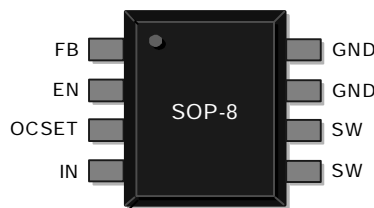
$I_{LED}=2A$



### Functional Block Diagram



### Pin Configurations



Pin No.	Name	Description
1	FB	This pin senses the feedback voltage to set the LED current. Connect this pin to a resistor ( $R_{FB}$ ) to set constant LED current by the following formula: $I_{LED} = 0.21V / R_{FB}$
2	EN	This pin allows an external control signal to turn-on/off this device. Float this pin or force it below 0.8V to turn-off this device, force it above 2V to turn-on this device. If this feature is not needed, connect this pin to IN directly.
3	OCSET	Add an external resistor from this pin to IN to set current Limit.
4	IN	The input pin of the step-down converter. A suitably large capacitor must be connected from this pin to ground to bypass noise on the input of the IC.
5,6	SW	The output pin of the step-down converter. This pin is the switching node that supplies power to the output. Connect a LC filter from this pin to the output load and a rectifier diode to the ground.
7,8	GND	The ground pin of the step-down converter. Connect this pin to the circuit ground.

## Absolute Maximum Ratings

Parameter	Rating
Input Voltage	25V
SW Pin Voltage Range	-0.5V ~ $V_{IN}+0.5V$
FB Pin Voltage Range	-0.3V ~ $V_{IN}$
EN Pin Voltage Range	-0.3V ~ $V_{IN}+0.3V$
Storage Temperature Range	-65°C ~ 150°C
Junction Temperature	150°C
Lead Soldering Temperature (10 sec)	300°C

These are stress ratings only and functional operation is not implied. Exposure to absolute maximum ratings for prolonged time periods may affect device reliability. All voltages are with respect to ground.

## Recommended Operating Conditions

Parameter	Rating
Input Voltage Range	3.6V ~ 23V
Ambient Temperature Range	-40°C ~ 85°C
Junction Temperature Range	-40°C ~ 125°C

These are conditions under which the device functions but the specifications might not be guaranteed. For guaranteed specifications and test conditions, please see the *Electrical Specifications*.

## Package Information

Parameter	Package	Symbol	Rating
Thermal Resistance (Junction to Case)	SOP-8	$\theta_{JC}$	20 °C/W
Thermal Resistance (Junction to Ambient)		$\theta_{JA}$	60 °C/W

## Electrical Specifications

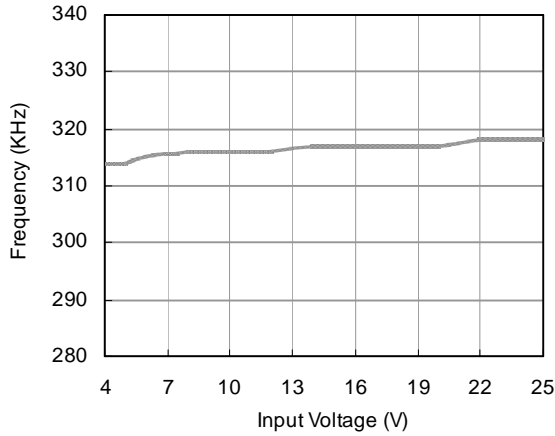
$V_{IN}=12V$ ,  $T_A=25^{\circ}C$ , unless otherwise noted.

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Feedback Voltage	$V_{FB}$	$I_{LOAD}=0.1A$	0.1995	0.21	0.2205	V
Efficiency	$\eta$	3 Series 1W LEDs, $I_{LED}=350mA$		96		%
Oscillation Frequency	$F_{OSC}$		240	300	360	KHz
Frequency of Short Circuit Protection	$F_{SCP}$		30	50	70	KHz
Duty Cycle	DC	$V_{FB}=0V$		100		%
		$V_{FB}=1.5V$		0		
Internal MOSFET ON Resistance	$R_{DS(ON)}$	$V_{IN}=5V$ , $V_{FB}=0V$		150		m $\Omega$
		$V_{IN}=12V$ , $V_{FB}=0V$		100		
Supply Current	$I_S$	$V_{FB}=0.5V$		3	10	mA
Shutdown Current	$I_{SD}$	$V_{EN}=0V$		1	10	$\mu A$
EN Pin Input Threshold Voltage	$V_{EN}$	Regulator OFF		1.3	0.8	V
		Regulator ON	2.0			
EN Pin Bias Current	$I_{EN}$	Regulator OFF		1		$\mu A$
		Regulator ON		20		
FB Pin Bias Current	$I_{FB}$	$I_{LOAD}=0.1A$		0.1	0.5	$\mu A$
OCSET Pin Bias Current	$I_{OCSET}$	$I_{LOAD}=0.1A$	75	90	105	$\mu A$
Line Regulation	$\Delta V_{LINE}$	$V_{IN}=3.6V \sim 23V$ , $I_{LOAD}=0.1A$		0.2		%/V
Load Regulation	$\Delta V_{LOAD}$	$I_{LOAD}=0.1A \sim 2A$		0.5		%/mA
Over Temperature Shutdown	$T_{SD}$			150		$^{\circ}C$
Over Temperature Shutdown Hysteresis	$T_{HYS}$			55		$^{\circ}C$

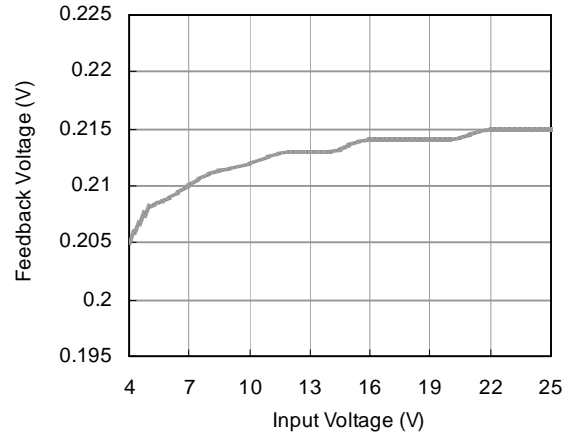
## Typical Performance Characteristics

$V_{IN}=12V$ ,  $T_A=25^{\circ}C$ , unless otherwise noted.

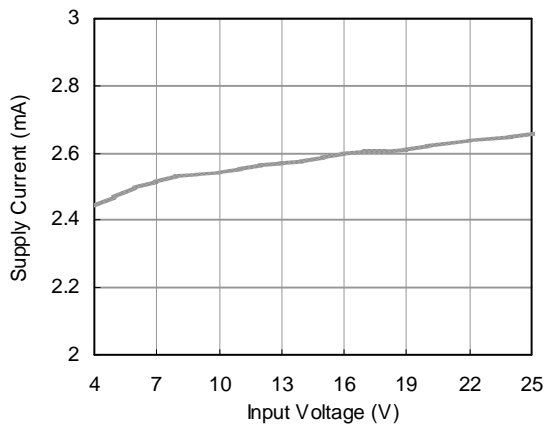
*Frequency vs. Input Voltage*



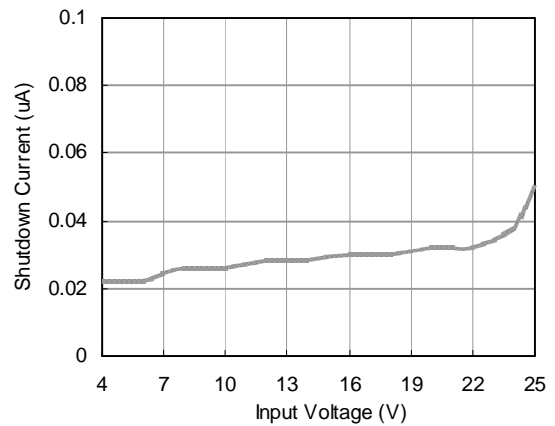
*Feedback Voltage vs. Input Voltage*



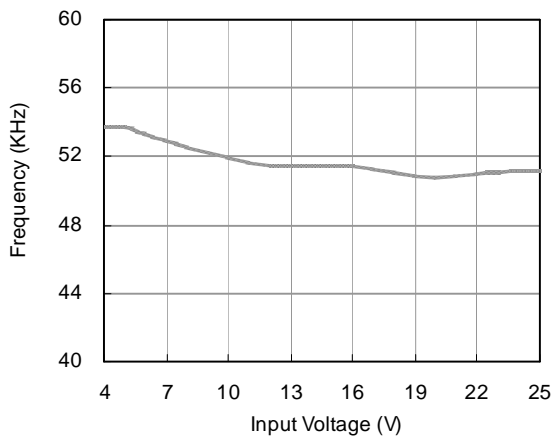
*Supply Current vs. Input Voltage*



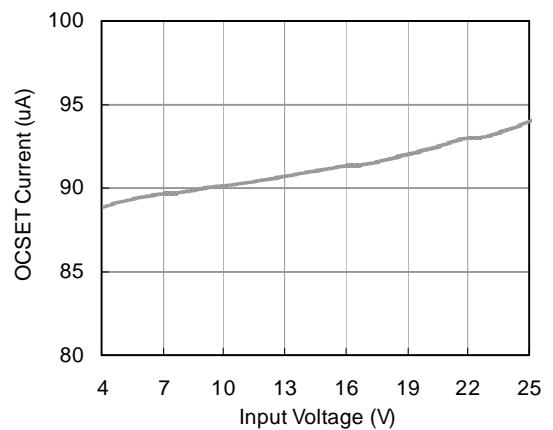
*Shutdown Current vs. Input Voltage*



*Short Circuit Frequency vs. Input Voltage*

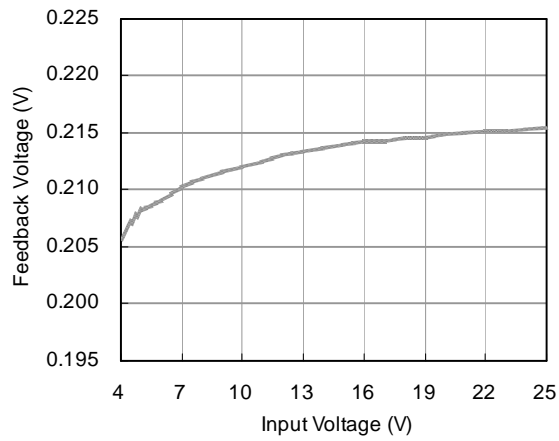


*OCSET Current vs. Input Voltage*

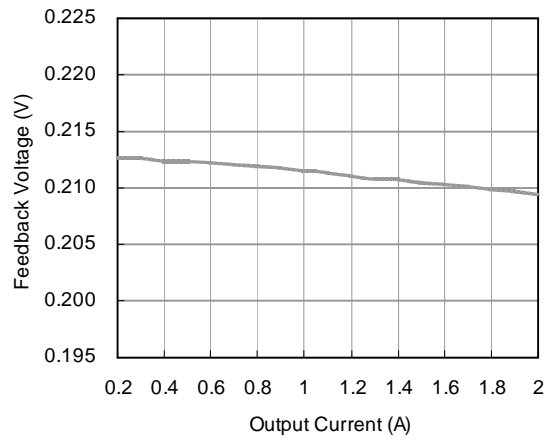


**Typical Performance Characteristics (Contd.)**

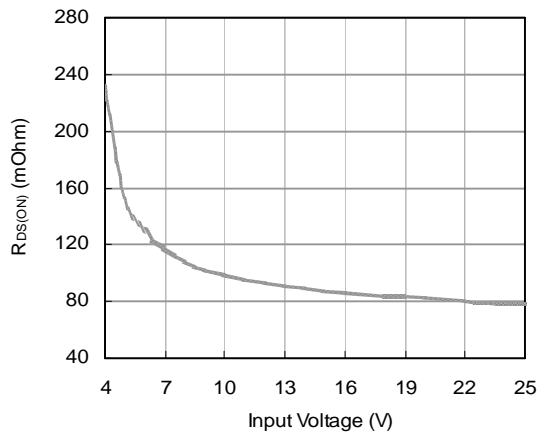
**Line Regulation**



**Load Regulation**



**Power MOSFET  $R_{DS(ON)}$  vs. Input Voltage**

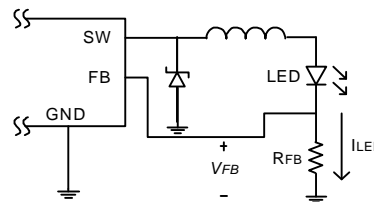




## Application Information

### LED Current Setting

This device is a constant current buck regulator that develops 0.21V reference voltage between FB and GND. Use 1% chip resistor to set the LED current and attain the better current accuracy. The LED current and the power dissipation on the current setting resistor can be calculated by the following formulas:



$$I_{LED} = 0.21V / R_{FB}$$

$$P_R = I_{LED} \times 0.21V$$

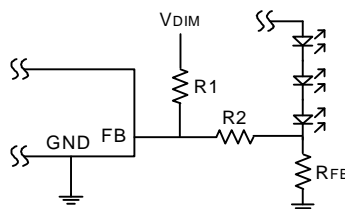
### Dimming Control

#### - Analog Dimming

The analog dimming control using a DC voltage ( $V_{DIM}$ ) is shown in the following circuit. As the  $V_{DIM}$  increases, the voltage drop on R2 increases. Thus the LED current decreases. The R1 and R2 must make the DC source current much larger than the FB bias current and much smaller than the LED current.

The LED current can be calculated by the following formula:

$$I_{LED} = \frac{V_{FB} \times (R1 + R2) - V_{DIM} \times R2}{R1 \times R_{FB}}$$



If the  $V_{DIM}$  is taken below the  $V_{FB}$ , the inverse will happen and the brightness will increase.

The analog dimming circuit can be tailored for different resistor value using the following formula:

$$R1 = \frac{(V_{DIM\_MAX} - V_{FB}) \times R2}{V_{FB} \times \left(1 - \frac{I_{LED\_DIMMED\_MIN}}{I_{LED\_UNDIMMED}}\right)}$$

Example:

$$V_{DIM\_MAX} = 5V$$

$$I_{LED\_DIMMED\_MIN} = 17.5mA \quad ; \quad V_{DIM}=5V$$

$$I_{LED\_UNDIMMED} = 350mA \quad ; \quad V_{DIM}=V_{FB}=0.21V$$

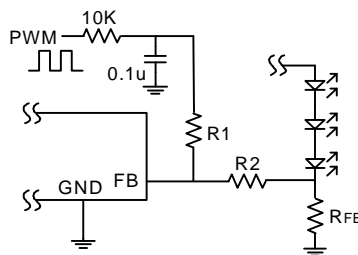
$$R2 = 5K\Omega \rightarrow R1 = 120K\Omega$$

The analog dimming circuit can be tailored for different dimming voltage range using the following formula:

$$V_{DIM} = V_{FB} \times \frac{R1}{R2} \times \left( 1 + \frac{R2}{R1} - \frac{I_{LED\_DIMMED\_MIN}}{I_{LED\_UNDIMMED}} \right)$$

**- Filtered PWM Dimming from FB**

Filtered PWM circuit can be used to replace the DC voltage source in dimming control. The circuit is shown in the following figure that is suitable for the high frequency PWM control signal.

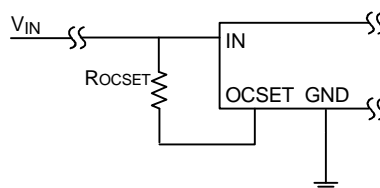


**Short Circuit Protection**

When the output is shorted to ground, the protection circuit will be triggered and force the oscillation frequency down to approximately 50KHz. The oscillation frequency will return to 300KHz once the output voltage or the feedback voltage rises above 0V.

**Current Limit Setting**

This device reserves OCSET pin to set the switching peak current. In general, the peak current must be 1.5 times of the continuous LED current. It can be calculated as below:

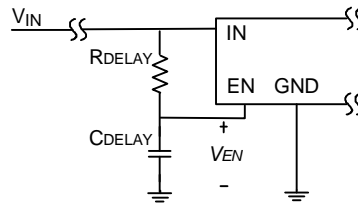


$$I_{CL} = (I_{OCSET} \times R_{OCSET}) / R_{DS(ON)}$$

Where  $I_{CL}$  is the current limit,  $I_{OCSET}$  is the OCSET bias current (90uA Typ.), and  $R_{DS(ON)}$  is the ON-resistance of the internal power MOSFET.

### Delay Start-up

The following circuit uses the EN pin to provide a time delay between the input voltage is applied and the output voltage comes up. As the instant of the input voltage rises, the charging of capacitor  $C_{DELAY}$  pulls the EN pin low, keeping the device off. Once the capacitor voltage rises above the EN pin threshold voltage, the device will start to operate. The start-up delay time can be calculated by the following formula:



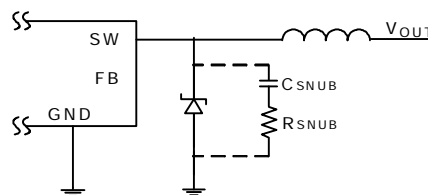
$$V_{IN} \times (1 - e^{-T/(R \times C)}) > V_{EN}$$

Where T is the start-up delay time, R is  $R_{DELAY}$ , C is  $C_{DELAY}$ , and the typical  $V_{EN}$  is 1.3V.

This feature is useful in situations where the input power source is limited in the amount of current it can deliver. It allows the input voltage to rise to a higher voltage before the device starts operating.

### Snubber Circuit

The simple RC snubber is used for voltage transient and ringing suppression. The high frequency ringing and voltage overshooting at the SW pin is caused by fast switching transition and resonating circuit parasitical elements in the power circuit. It maybe generates EMI and interferes with circuit performance. Reserve a snubber circuit in the PC board is preferred to damp the ringing due to the parasitical capacitors and inductors of layout. The following circuit is a simple RC snubber:



Choose the value of RC network by the following procedure:

- (1) Measure the voltage ringing frequency ( $f_R$ ) of the SW pin.
- (2) Find a small capacitor and place it across the SW pin and the GND pin to damp the ringing frequency by half.
- (3) The parasitical capacitance ( $C_{PAR}$ ) at the SW pin is 1/3 the value of the added capacitance

above. The parasitical inductance ( $L_{PAR}$ ) at the SW pin is:

$$L_{PAR} = \frac{1}{(2\pi f_R)^2 \times C_{PAR}}$$

(4) Select the value of  $C_{SNUB}$  that should be more than 2~4 times the value of  $C_{PAR}$  but must be small enough so that the power dissipation of  $R_{SNUB}$  is kept to a minimum.

The power rating of  $R_{SNUB}$  can be calculated by following formula:

$$P_{RSNUB} = C_{SNUB} \times V_{IN}^2 \times f_s$$

(5) Calculate the value of  $R_{SNUB}$  by the following formula and adjust the value to meet the expectative peak voltage.

$$R_{SNUB} = 2\pi \times f_R \times L_{PAR}$$

### *Thermal Considerations*

Thermal protection limits total power dissipation in this device. When the junction temperature reaches approximately 150°C, the thermal sensor signals the shutdown logic turning off this device. The thermal sensor will turn this device on again after the IC's junction temperature cools by approximately 55°C. For continuous operation, do not exceed the maximum operation junction temperature 125°C.

The power dissipation across this device can be calculated by the following formula:

$$P_D = I_{LED}^2 \times R_{DS(ON)} \times \frac{V_{OUT}}{V_{IN}} + \frac{1}{2} \times V_{IN} \times I_{LED} \times (t_r + t_f) \times f_s + Q_g \times V_{GS} \times f_s + V_{IN} \times I_s$$

Where  $f_s$  is the 300KHz switching frequency,  $(t_r+t_f)$  is the switching time that is approximately 30ns,  $Q_g$  is the power MOSFET gate charge that is approximately 10nC,  $V_{GS}$  is the gate voltage of the power MOSFET that is approximately equal  $V_{IN}$ , and  $I_s$  is the 3mA supply current.

The maximum power dissipation of this device depends on the thermal resistance of the IC package and PCB layout, the temperature difference between the die junction and ambient air, and the rate of airflow. The maximum power dissipation can be calculated by the following formula:

$$P_{D(MAX)} = \frac{(T_J - T_A)}{\theta_{JA}}$$

Where  $T_J - T_A$  is the temperature difference between the die junction and surrounding environment,  $\theta_{JA}$  is the thermal resistance from the junction to the surrounding environment.

The value of junction to case thermal resistance  $\theta_{JC}$  is also popular to users. This thermal parameter is convenient for users to estimate the internal junction operated temperature of packages while IC operating. The operated junction temperature can be calculated by the

following formula:

$$T_J = T_C + P_D \times \theta_{JC}$$

$T_C$  is the package case temperature measured by thermal sensor. Therefore it's easy to estimate the junction temperature by any condition.

There are many factors affect the thermal resistance. Some of these factors include trace width, copper thickness, total PCB copper area, and etc. For the best thermal performance, wide copper traces and generous amounts of PCB copper should be used in the board layout. If further improve thermal characteristics are needed, double sided and multi-layer PCB with large copper areas and airflow will be recommended.

### *Layout Considerations*

PC board layout is very important, especially for switching regulators of high frequencies and large peak currents. A good layout minimizes EMI on the feedback path and provides best efficiency. The following layout guides should be used to ensure proper operation of this device.

- (1) The power charge path that consists of the IN trace, the SW trace, the external inductor and the GND trace should be kept wide and as short as possible.
- (2) The power discharge path that consists of the SW trace, the external inductor, the rectifier diode and the GND trace should be kept wide and as short as possible.
- (3) The feedback path of voltage divider should be close to the FB pin and keep noisy traces away; also keep them separate using grounded copper.
- (4) The input capacitors should be close to the regulator and rectifier diode.
- (5) The output capacitors should be close to the load.

## Component Selection

### Inductor Selection

The conduction mode of power stage depends on input voltage, output voltage, LED current, and the value of the inductor. Select an inductor to maintain this device operating in continuous conduction mode (CCM). The minimum value of inductor can be determined by the following procedure.

(1) Calculate the minimum duty ratio:

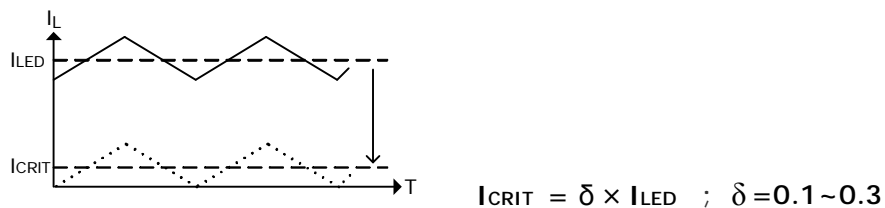
$$D_{(MIN)} = \frac{V_{OUT} + I_{LED} \times DCR + V_F}{V_{IN(MAX)} - I_{LED} \times R_{DS(ON)} + V_F} = \frac{T_{ON}}{T_S}$$

Where DCR is the DC resistance of the inductor,  $V_F$  is the forward voltage of the rectifier diode, and  $T_S$  is the switching period.

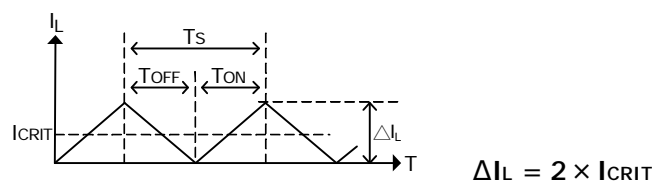
This formula can be simplified as below:

$$D_{(MIN)} = \frac{V_{OUT}}{V_{IN(MAX)}} = \frac{T_{ON}}{T_S} ; 0 \leq D \leq 1$$

(2) Define a minimum LED current that is approximately 10%~30% of maximum LED current to maintain continuous conduction mode, usually referred to as the critical current ( $I_{CRIT}$ ).



(3) Calculate the inductor ripple current ( $\Delta I_L$ ). In steady state conditions, the inductor ripple current increase, ( $\Delta I_{L+}$ ), during the ON time and the current decrease, ( $\Delta I_{L-}$ ), during the OFF time must be equal.



(4) Calculate the minimum value of inductor use maximum input voltage. That is the worst case condition because it gives the maximum  $\Delta I_L$ .

$$L \geq \frac{[V_{IN(MAX)} - I_{LED} \times (R_{DS(ON)} + DCR) - V_{OUT}] \times D_{(MIN)}}{\Delta I_L \times f_s}$$

This formula can be simplified to

$$L \geq \frac{(V_{IN(MAX)} - V_{OUT}) \times D_{(MIN)}}{\Delta I_L \times f_s}$$

The higher inductance results in lower output ripple current and ripple voltage. But it requires larger physical size and price.

(5) Calculate the inductor peak current and choose a suitable inductor to prevent saturation.

$$I_{L(\text{PEAK})} = I_{\text{LED}} + \frac{\Delta I_L}{2}$$

Coil inductors and surface mount inductors are all available. The surface mount inductors can reduce the board size but they are more expensive and its larger DC resistance results in more conduction loss. The power dissipation is due to the DC resistance can be calculated as below:

$$P_{D\_INDUCTOR} = I_{\text{LED}}^2 \times \text{DCR}$$

### Rectifier Diode Selection

The rectifier diode provides a current path for the inductor current when the internal power MOSFET turns off. The best solution is Schottky diode, and some parameters about the diode must be take care as below:

- (1) The forward current rating must be higher than the continuous LED current.
- (2) The reverse voltage rating must be higher than the maximum input voltage.
- (3) The lower forward voltage will reduce the conduction loss.
- (4) The faster reverse recovery time will reduce the switching loss, but it is very small compared to conduction loss.
- (5) The power dissipation can be calculated by the forward voltage and output current for the time that the diode is conducting.

$$P_{D\_DIODE} = I_{\text{LED}} \times V_F \times (1 - D)$$

### Output Capacitor Selection

The functions of the output capacitor are to store energy and maintain the output voltage. The low ESR (Equivalent Series Resistance) capacitors are preferred to reduce the output ripple voltage ( $\Delta V_{\text{OUT}}$ ) and conduction loss. The output ripple voltage can be calculated as below:

$$\Delta V_{\text{OUT}} = \Delta I_L \times \left( \text{ESR}_{\text{COUT}} + \frac{1}{8 \times f_s \times C_{\text{OUT}}} \right)$$

Choose suitable capacitors must define the expectative value of output ripple voltage first.

The ESR of the aluminum electrolytic or the tantalum capacitor is an important parameter to determine the output ripple voltage. But the manufacturers usually do not specify ESR in the specifications. Assuming the capacitance is enough results in the output ripple voltage that due to

the capacitance can be ignored, the ESR should be limited to achieve the expectative output ripple voltage. The maximum ESR can be calculated as below:

$$ESR_{\_COUT} \leq \frac{\Delta V_{OUT}}{\Delta I_L}$$

Choose the output capacitance by the average value of the RC product as below:

$$C_{OUT} \approx \frac{50 \sim 80 \times 10^{-6}}{ESR_{\_COUT}}$$

The capacitors' ESR and ripple current result in power dissipation that will increase the internal temperature. Usually, the capacitors' manufacturers specify ripple current ratings and should not be exceeded to prevent excessive temperature shorten the life time. Choose a smaller inductor causes higher ripple current which maybe result in the capacitor overstress. The RMS ripple current flowing through the output capacitor and power dissipation can be calculated as below:

$$I_{RMS\_COUT} = \frac{\Delta I_L}{\sqrt{12}} = \Delta I_L \times 0.289$$

$$P_{D\_COUT} = (I_{RMS\_COUT})^2 \times ESR_{\_COUT}$$

The capacitor's ESL (Equivalent Series Inductance) maybe causes ringing in the low MHz region. Choose low ESL capacitors, limiting lead length of PCB and capacitor, and parallel connecting several smaller capacitors to replace with a larger one will reduce the ringing phenomenon.

### *Input Capacitor Selection*

The input capacitor is required to supply current to the regulator and maintain the DC input voltage. Low ESR capacitors are preferred those provide the better performance and the less ripple voltage.

The input capacitors need an adequate RMS current rating. It can be calculated by following formula and should not be exceeded.

$$I_{RMS\_CIN} = I_{LED(MAX)} \times \sqrt{D \times (1 - D)}$$

This formula has a maximum at  $V_{IN}=2V_{OUT}$ . That is the worst case and the above formula can be simplified to:

$$I_{RMS\_CIN} = \frac{I_{LED(MAX)}}{2}$$

Therefore, choose a suitable capacitor at input whose ripple current rating must greater than half of the maximum LED current.



The input ripple voltage ( $\Delta V_{IN}$ ) mainly depends on the input capacitor's ESR and its capacitance. Assuming the input current of the regulator is constant, the required input capacitance for a given input ripple voltage can be calculated as below:

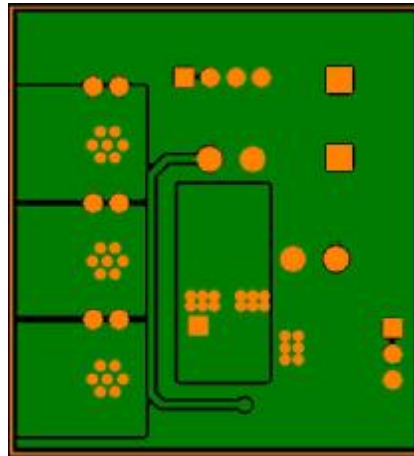
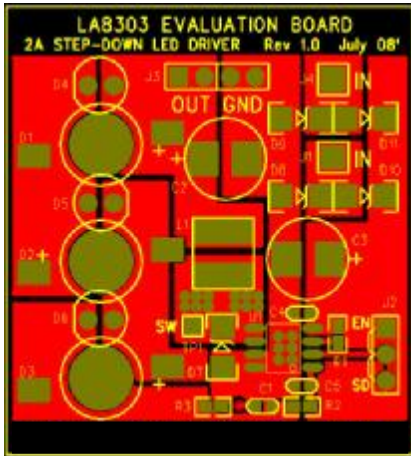
$$C_{IN} = \frac{I_{LED(MAX)} \times D \times (1 - D)}{f_S \times (\Delta V_{IN} - I_{LED(MAX)} \times ESR_{-CIN})}$$

If using aluminum electrolytic or tantalum input capacitors, parallel connecting 0.1uF bypass capacitor as close to the regulator as possible. If using ceramic capacitor, make sure the capacitance is enough to prevent the excessive input ripple current.

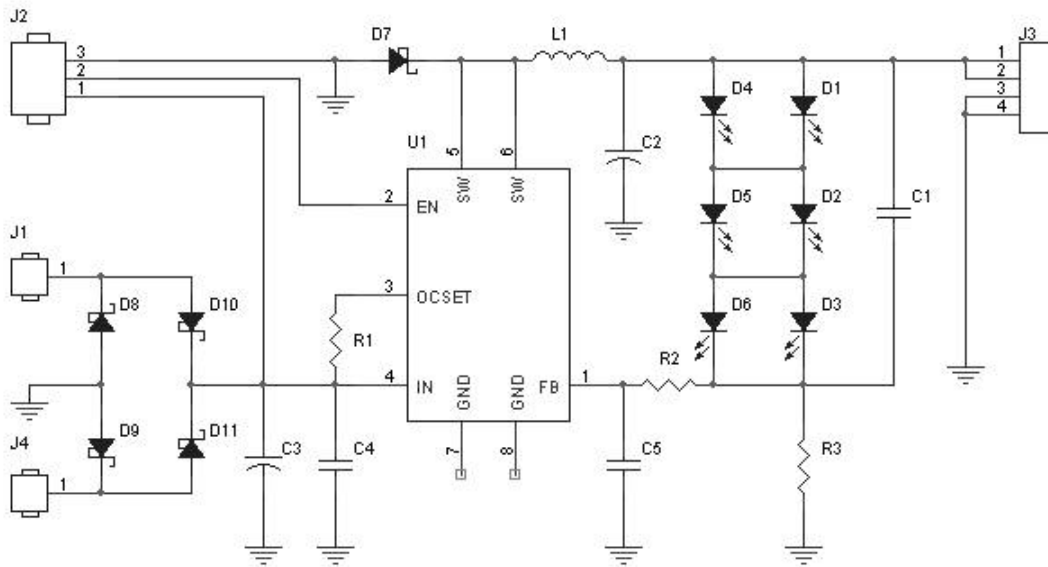
The power dissipation of input capacitor causes a small conduction loss can be calculated as below:

$$P_{D\_CIN} = (I_{RMS\_CIN})^2 \times ESR_{-CIN}$$

### Evaluation Board Layout



### Evaluation Board Schematic

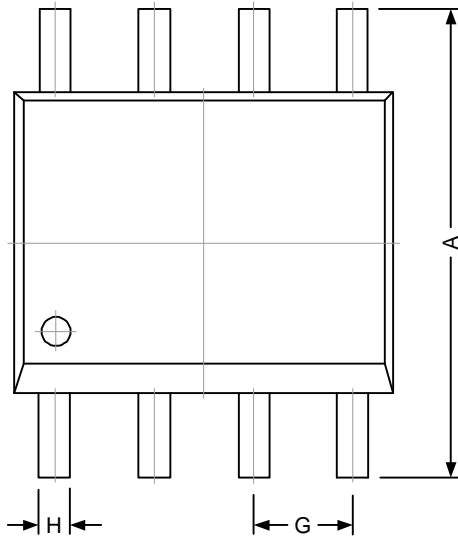


### Key Components Supplier

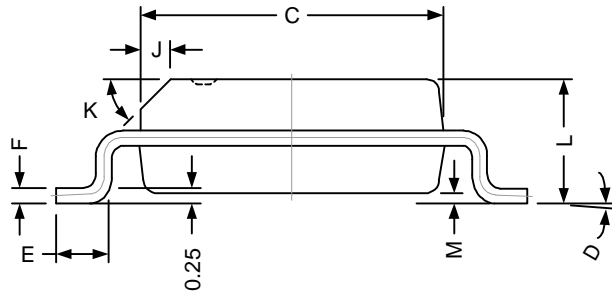
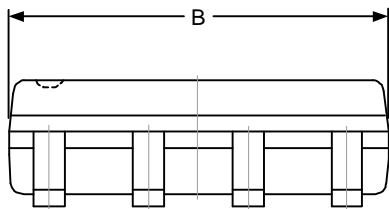
Item	Manufacturer	Website	Manufacturer	Website
Inductor	Chilisin	<a href="http://www.chilisin.com.tw">www.chilisin.com.tw</a>	WE	<a href="http://www.we-online.com">www.we-online.com</a>
Schottky Diode	Formosa	<a href="http://www.formosams.com">www.formosams.com</a>	Gulf	<a href="http://www.gulfsemi.com">www.gulfsemi.com</a>
Tantalum Capacitor	Kemet	<a href="http://www.kemet.com">www.kemet.com</a>		
Electrolytic Capacitor	NCC	<a href="http://www.chemi-con.co.jp">www.chemi-con.co.jp</a>	Jamicon	<a href="http://www.jamicon.com.tw">www.jamicon.com.tw</a>
SMD Capacitor	Yageo	<a href="http://www.yageo.com">www.yageo.com</a>	Taiyo Yuden	<a href="http://www.yuden.co.jp">www.yuden.co.jp</a>
SMD Resistor	Yageo	<a href="http://www.yageo.com">www.yageo.com</a>		

Package Outline

SOP-8



REF.	DIMENSIONS	
	Millimeter	
	Min.	Max.
A	5.80	6.20
B	4.80	5.00
C	3.80	4.00
D	0°	8°
E	0.40	0.90
F	0.19	0.25
M	0.10	0.25
H	0.35	0.49
L	1.35	1.75
J	0.375 REF.	
K	45°	
G	1.27 TYP.	



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