General Description

The 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. This device includes an error amplifier, oscillation circuit, P-channel power MOSFET, and etc. The internal reference voltage source provides a 0.21V low feedback voltage that can reduce the power dissipation of the current setting resistor, and improve conversion efficiency.

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 input voltage, this device can drive up to 15pcs 1W LED (3S-5P) with constant 350mA LED current.

The LA8303 provides an enable function that can be controlled by external logic signal. It also provides excellent regulation during line or load transient due to the internal compensation. Other features of thermal protection, current limit, short circuit protection, and dimming control are also included. Due to the low $R_{DS(ON)}$ of the power MOSFET, the LA8303 provides a high efficiency step-down application. It can also operate with a maximum duty cycle of 100% for use in low drop-out conditions.

The package is available in a standard SOP-8L.

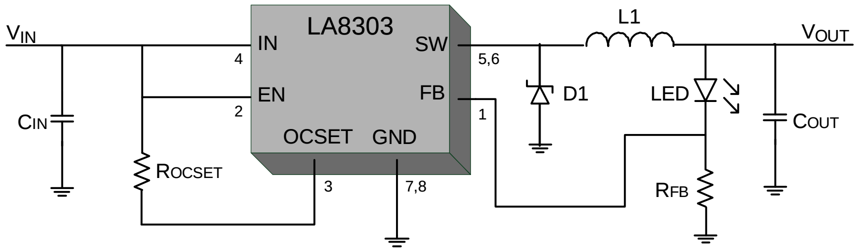
Features

- Low Feedback Voltage 0.21V
- Up to 96% Efficiency
- Wide Operation Voltage from 3.6V to 23V
- Driving up to 15 LEDs (1W 3S-5P) at $12V_{IN}$
- No External Compensation Required
- Great Output Capability: 2A
- Oscillation Frequency: 300KHz
- PWM or Analog Dimming Control
- Built-in P-channel MOSFET
- External ON/OFF Control Function
- Low Shutdown Current: 1uA
- Current Limit and Thermal Protection
- Short Circuit Protection
- SOP-8L Package
- All Products meet Rohs Standard

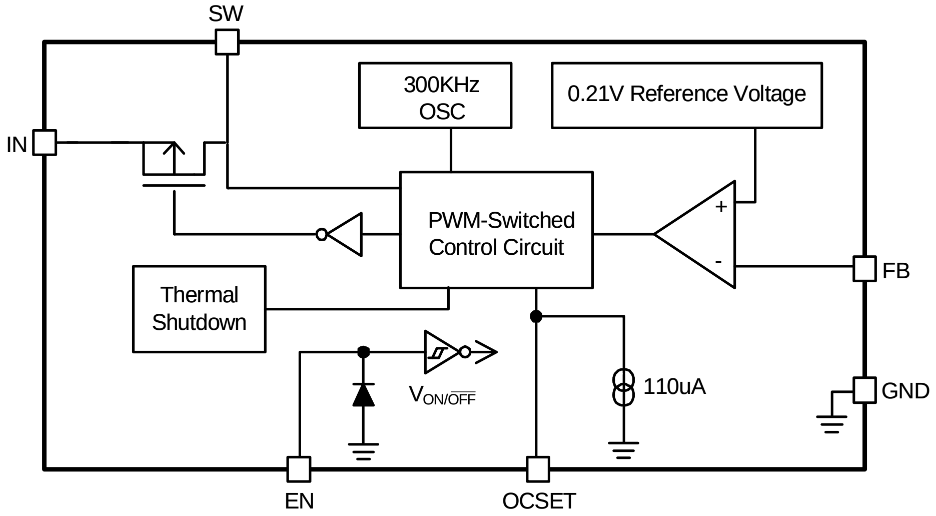
Applications

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

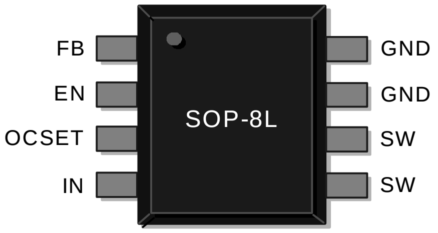
Typical Application



v Functional Block Diagram

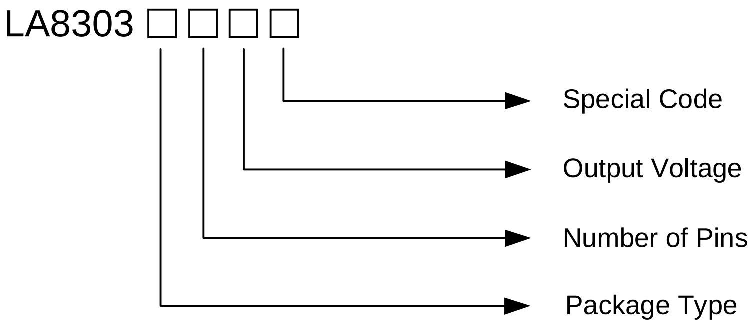


v Pin Configurations



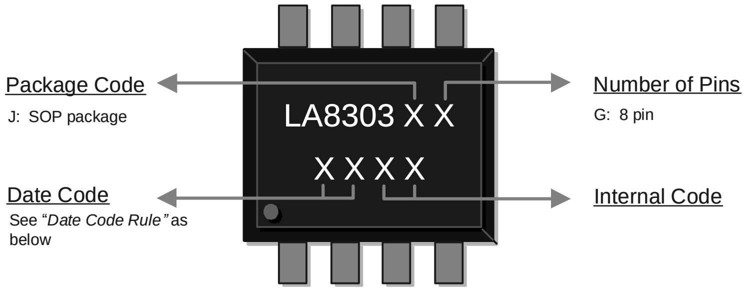
Pin No.	Name	Description
1	FB	This pin senses the feedback voltage to set the LED current. Connect a resistor (R_{FB}) to set LED current by the following formula: $I_{LED} = 0.21V / R_{FB}$
2	EN	This pin allows an external logic control signal to turn-on/off this device. Float this pin or drive it to low level turns this device off, drive it to high level turns this device on. If this feature is not needed, connect this pin to IN directly.
3	OCSET	Add an external resistor from this pin to IN pin to set peak current.
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.

Ordering Information



Package Type	Number of Pins	Output Voltage	Special Code
J: SOP	G: 8 pin	Blank: Adjustable	Blank: Original

Marking Information



Data Code Rule

Year / Week	xxx0	xxx1	xxx2	xxx3	xxx4	xxx5	xxx6	xxx7	xxx8	xxx9
01	AA	CA	EA	GA	IA	KA	MA	OA	RA	TA
02	AB	CB	EB	GB	IB	KB	MB	OB	RB	TB
03	AC	CC	EC	GC	IC	KC	MC	OC	RC	TC
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.	.	.	.	.	.	.	.	.	.	.
25	AY	CY	EY	GY	IY	KY	MY	OY	RY	TY
26	AZ	CZ	EZ	GZ	IZ	KZ	MZ	OZ	RZ	TZ
27	BA	DA	FA	HA	JA	LA	NA	PA	SA	UA
28	BB	DB	FB	HB	JB	LB	NB	PB	SB	UB
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
50	BX	DX	FX	HX	JX	LX	NX	PX	SX	UX
51	BY	DY	FY	HY	JY	LY	NY	PY	SY	UY
52	BZ	DZ	FZ	HZ	JZ	LZ	NZ	PZ	SZ	UZ

v 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.

v Recommended Operating Conditions

Parameter	**Rating**
Input Voltage Range	3.6V ~ 23V
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*.

v Package Information

Parameter	**Package**	**Symbol**	**Maximum**	**Unit**
Thermal Resistance (Junction to Case)	SOP-8L	θ_{JC}	20	°C / W
Thermal Resistance (Junction to Ambient)		θ_{JA}	60	°C / W

v Electrical Specifications

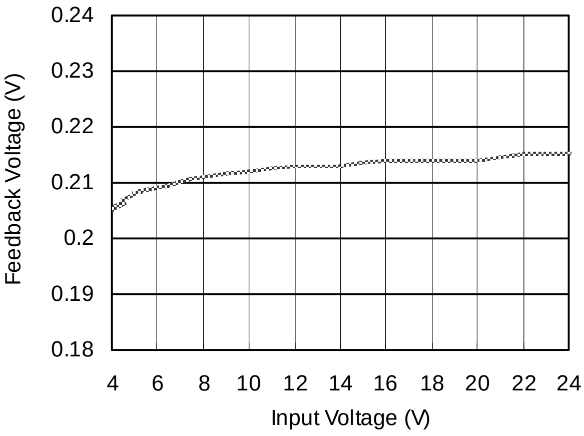
V_{IN}=12V, T_A=25°C, unless otherwise noted.

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Feedback Voltage	V_{FB}	I_{LOAD}=0.2A	0.1995	0.21	0.2205	V
Efficiency	η	3 Series 1W LEDs, I_{LED}=350mA		96		%
Oscillation Frequency	F_{OSC}	V_{IN}=3.6~23V, I_{LOAD}=0.2~2A	240	300	360	KHz
Frequency of Short Circuit Protection	F_{SCP}	V_{IN}=3.6~23V	30	50	70	KHz
Duty Cycle	DC	V_{FB}=0V force driver on		100		%
		V_{FB}=0.5V force driver off		0		
Internal MOSFET On Resistance	$R_{DS(ON)}$	V_{IN}=5V, V_{FB}=0V		160	180	mΩ
		V_{IN}=12V, V_{FB}=0V		100	120	
Quiescent Current	I_Q	V_{IN}=3.6V~23V V_{FB}=0.5V force drive off		3	10	mA
Shutdown Current	I_S	EN pin = GND		1	10	uA
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		uA
		Regulator ON		20		
FB Pin Bias Current	I_{FB}			0.1	0.5	uA
OCSET Pin Bias Current	I_{OCSET}		95	110	125	uA
Line Regulation	$\triangle V_{LINE}$	V_{IN}=3.6V~23V, I_{LOAD} =0.2A		0.2		%/V
Load Regulation	$\triangle V_{LOAD}$	I_{LOAD}=0.2A~2A		0.5		%/A
Over Temperature Shutdown	T_{SD}			150		°C
Over Temperature Shutdown Hysteresis	T_{HYS}			55		°C

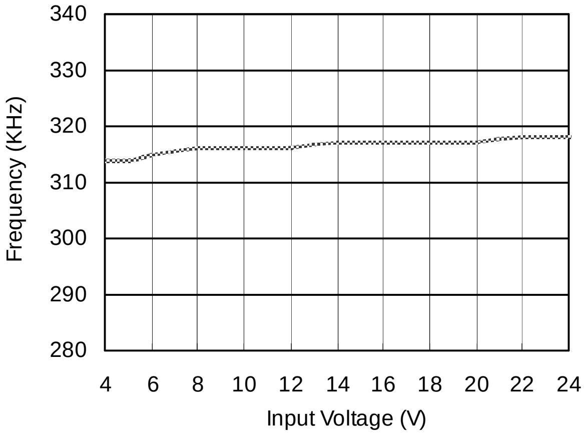
Typical Performance Characteristics

V_{IN}=12V, T_A=25°C, unless otherwise noted.

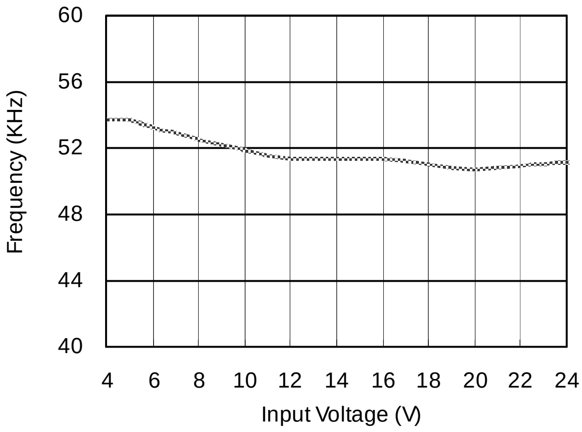
Feedback Voltage vs. Input Voltage



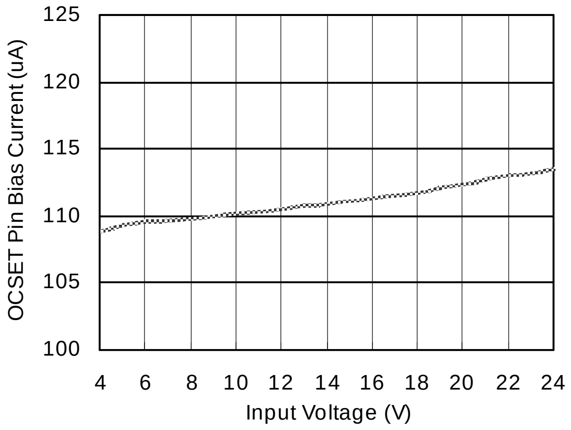
Frequency vs. vs. Input Voltage



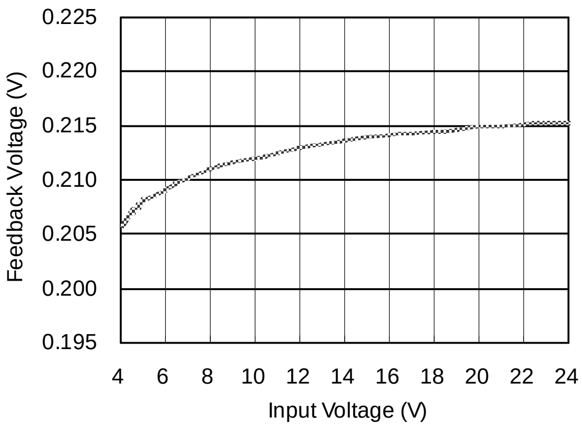
Short Circuit Frequency vs. Input Voltage



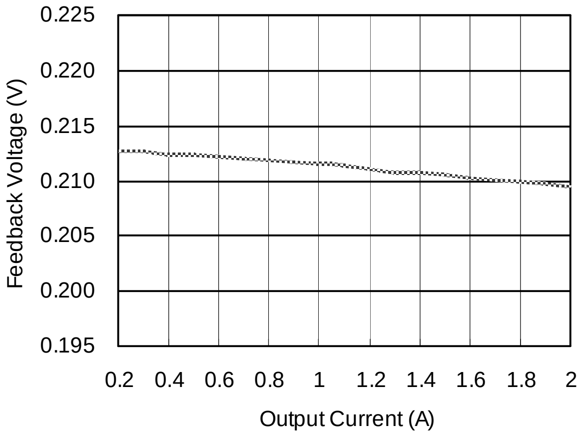
OCSET Current vs. Input Voltage

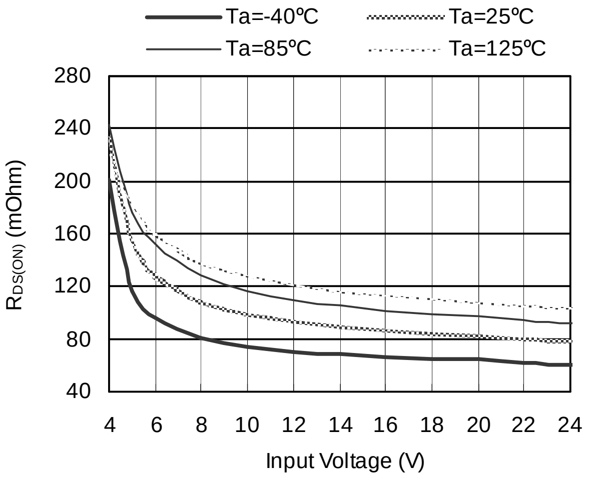


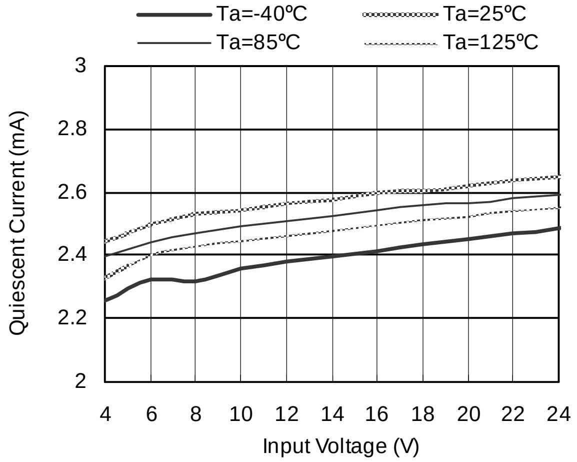
Line Regulation

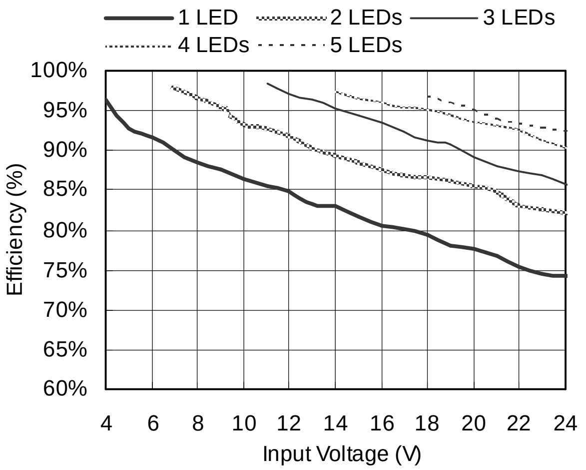


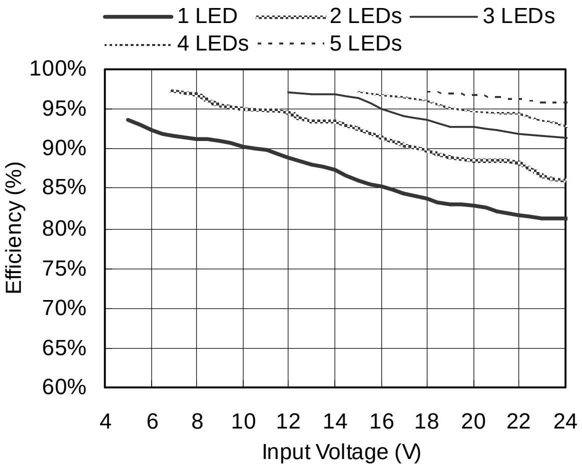
Load Regulation

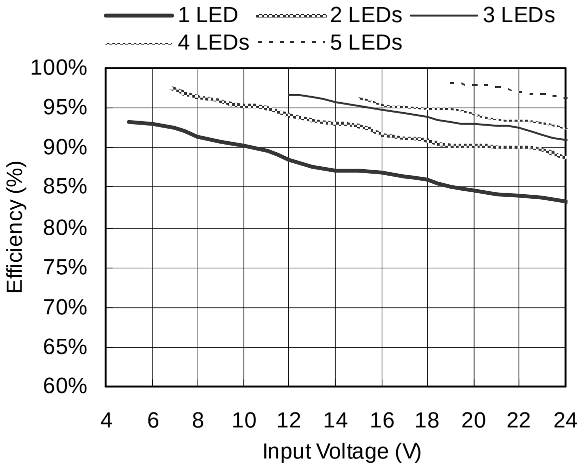


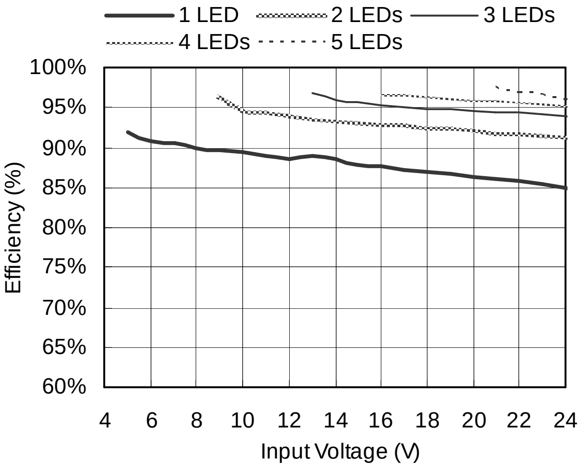

$R_{DS(ON)}$ vs. Input Voltage


Quiescent Current vs. Input Voltage


Efficiency (I_{LED}=350mA)


Efficiency (I_{LED}=700mA)


Efficiency (I_{LED}=1A)


Efficiency (I_{LED}=2A)

v Application Information

LED Current Setting

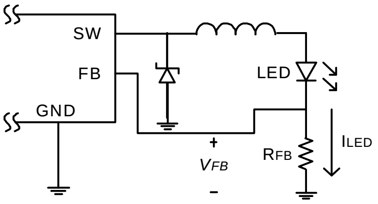
This device is a constant current buck regulator that develops 0.21V reference voltage between the feedback pin and ground pin. Therefore, the LED current can be calculated by R_{FB} and V_{FB}. Use 1% chip resistors to attain the better current accuracy.

The LED current is given by the following formula:

$$I_{LED} = \frac{V_{FB}}{R_{FB}} \quad ; V_{FB}=0.21V$$

The resistor's power dissipation can be calculated by the following formula:

$$P_{RFB} = I_{LED} \times V_{FB}$$



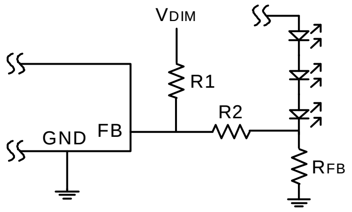
Dimming Control

Analog Dimming Control

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 formulas:

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

Example:

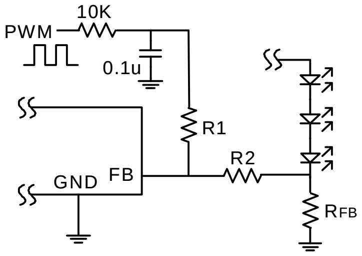
V_{DIM_MAX} = 5V
$I_{LED\_DIMMED\_MIN}$ = 17.5mA ; V_{DIM}=5V
$I_{LED\_UNDIMMED}$ = 350mA ; V_{DIM}=V_{FB}=0.21V
R2 = 5KOhm → R1 = 120KOhm

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

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

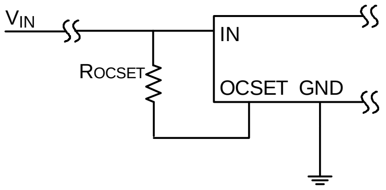
Filtered PWM Dimming from FB

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.



Current Limit Setting

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



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

Where:

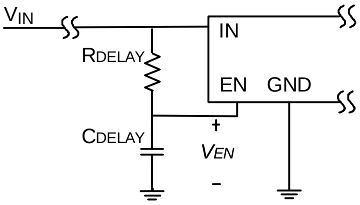
I_{PK}; Peak Current Limit
I_{OCSET}; OCSET Pin Bias Current
$R_{DS(ON)}$; Power MOSFET On-Resistance

Short Circuit Protection

This device includes 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 the normal value once the output voltage or the feedback voltage rises above 0V.

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.



For example, setting at V_{IN}=12V, R_{DELAY}=100KΩ, C_{DELAY}=0.1uF. The start-up delay time can be calculated as below:

$$V_C = V_{IN} \times (1 - e^{-T/t}) \geq V_{EN}$$

$$; t = R_{DELAY} \times C_{DELAY}$$

$$T \geq 1.147ms$$

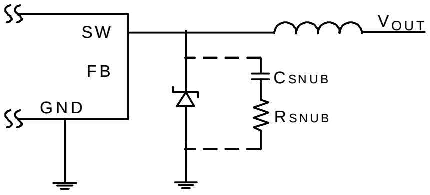
Where V_C is the capacitor voltage, V_{EN} is the EN threshold voltage (1.3V$_{\_TYP.}$), T is the delay time, and τ is the RC constant.

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 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:

$$P_D = I_{LED}{}^2 \times R_{DS(ON)} \times D + \frac{1}{2} \times V_{IN} \times I_{LED} \times (t_r + t_f) \times f_S + Q_{GATE} \times V_{GS} \times f_S + I_Q \times V_{IN}$$

Where:

D: Duty Cycle

f_S: Switching Frequency

V_{GS}: Power MOSFET Gate Voltage

I_Q: Quiescent Current

The tr, tf, and Q_{GATE} are the rising, falling time, and gate charge of the power MOSFET. The typical value of (tr+tf) is approximately 28ns, and the Q_{GATE} is approximately 10nC. The V_{GS} is approximately equal V_{IN}.

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, θ_{JA} is the thermal resistance from the junction to the surrounding environment.

The value of junction to case thermal resistance θ_{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, 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, external inductor, external 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. The output capacitors should be close to the load.

(5) Keep the (-) plates of input and output capacitors as close as possible.

v Component Selection

1. 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:

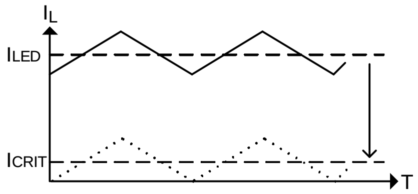
$$D_{(MIN)} = \frac{V_{OUT} + I_{LED} \times R_L + V_F}{V_{IN(MAX)} - I_{LED} \times R_{DS(ON)} + V_F} = \frac{T_{ON}}{T_S}$$

Where R_L is the DC resistance of external inductor, V_F is the forward voltage of external diode, and Ts is the switching period.

This formula can be simplified to

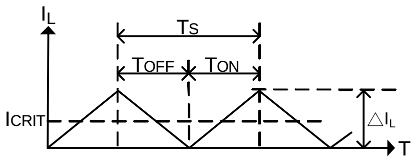
$$D_{(MIN)} = \frac{V_{OUT}}{V_{IN(MAX)}} = \frac{T_{ON}}{T_S} \quad ; \quad 0 \leq D \leq 1$$

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



$$I_{CRIT} = d \times I_{LED} \quad ; \quad \delta = 0.1\text{~}0.3$$

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



$$\Delta I_L = 2 \times I_{CRIT}$$

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

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

This formula can be simplified to

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

The higher value inductor results in lower output ripple current and ripple voltage. It also reduces the conduction loss. But higher value inductor requires larger physical size and price.

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

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

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:

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

2. Output Rectifier Diode Selection

The rectifier diode provides a current path for the inductor current when the internal power switch of the converter 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 of diode must be higher than the continuous LED current.

(2) The reverse voltage rating of diode must be higher than the maximum input voltage.

(3) The lower forward voltage of diode will reduce the conduction loss.

(4) The faster reverse recovery time of diode 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 LED current for the time that the diode is conducting.

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

3. 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 ($\triangle V_{OUT}$) and conduction loss. The output ripple voltage can be calculated as below:

$$\Delta V_{OUT} = \Delta I_L \times \left(ESR\_C_{OUT} + \frac{1}{8 \times f_S \times C_{OUT}} \right)$$

The ESR of the aluminum electrolytic or tantalum output 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 is 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:

$$ESR\_C_{OUT} \le \frac{\Delta V_{OUT}}{\Delta I_L}$$

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

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

The ESR and ripple current results power dissipation in the capacitor. It 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:

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

$$P_{D\_COUT} = (I_{RMS}\_C_{OUT})^2 \times ESR\_C_{OUT}$$

Besides, 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.

4. 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.

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

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

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

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

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

(2) The input ripple voltage ($\triangle V_{IN}$) 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:

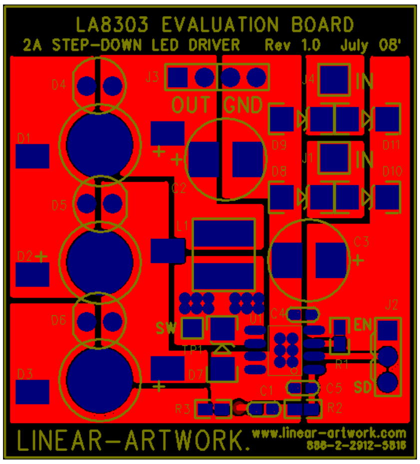
$$C_{IN} = \frac{I_{LED(MAX)} \times D \times (1 - D)}{f_S \times (\Delta V_{IN} - I_{LED(MAX)} \times ESR\_C_{IN})}$$

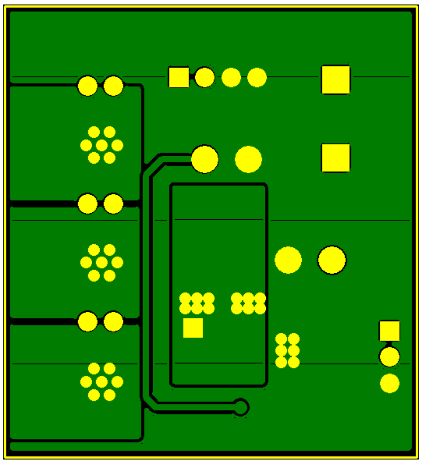
If using aluminum electrolytic or tantalum input capacitors, parallel connecting a 0.1uF ceramic capacitor as close to the IN pin of regulator as possible. If using ceramic capacitor, make sure the capacitance is enough to prevent the excessive input ripple current.

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

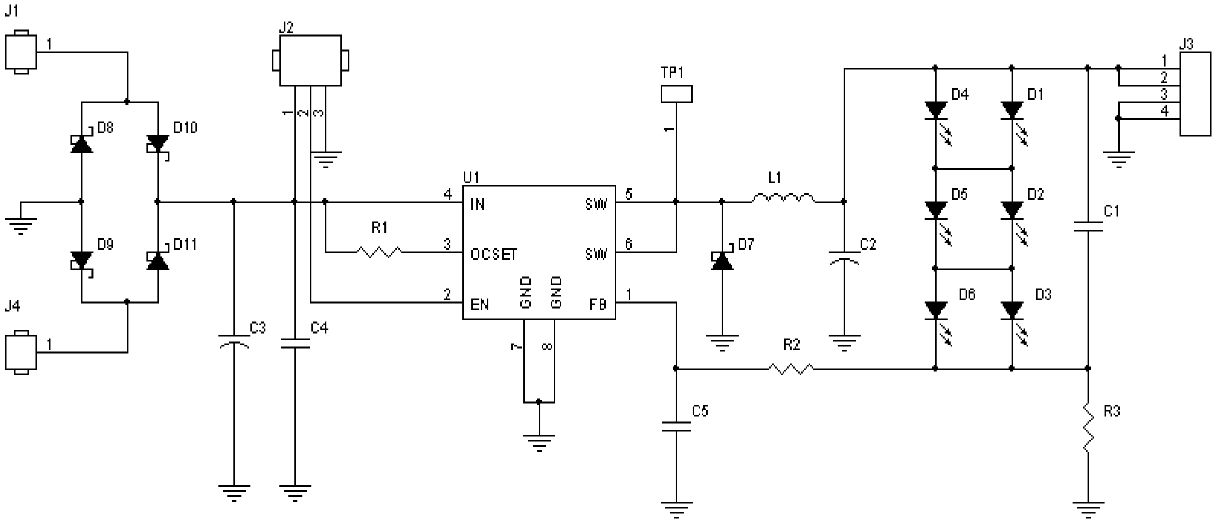
$$P_{D\_CIN} = (I_{RMS}\_C_{IN})^2 \times ESR\_C_{IN}$$

v Evaluation Board Layout





v Evaluation Board Schematic

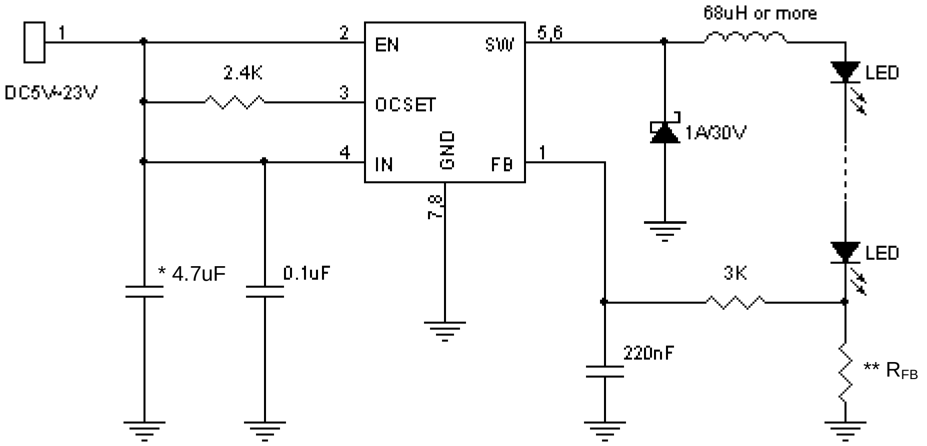


v Key Components Supplier

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

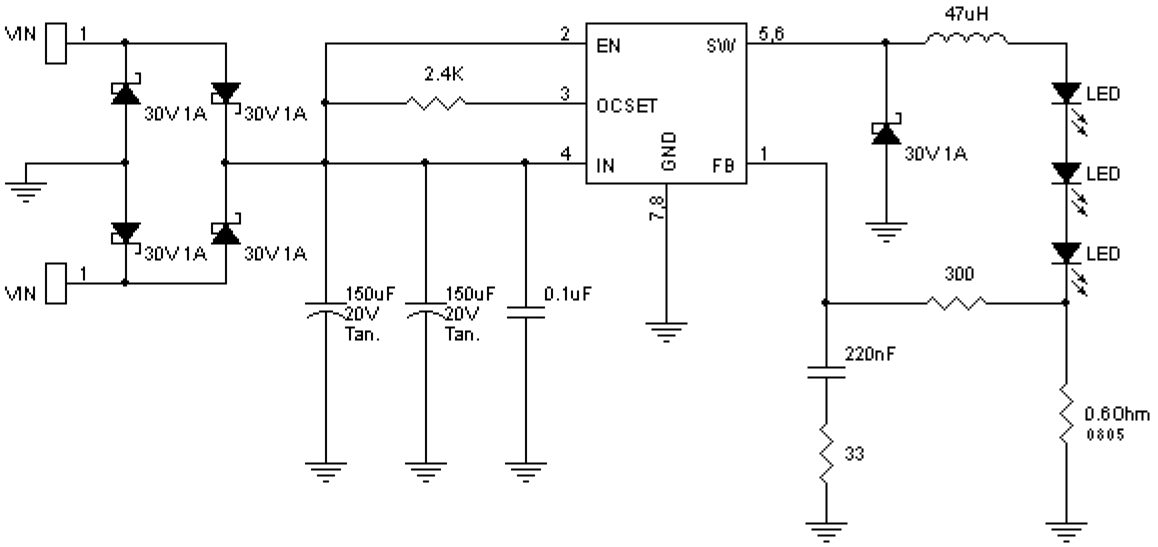
v Typical Application Circuits

♦ 1W ~ 5W High Brightness LED Application



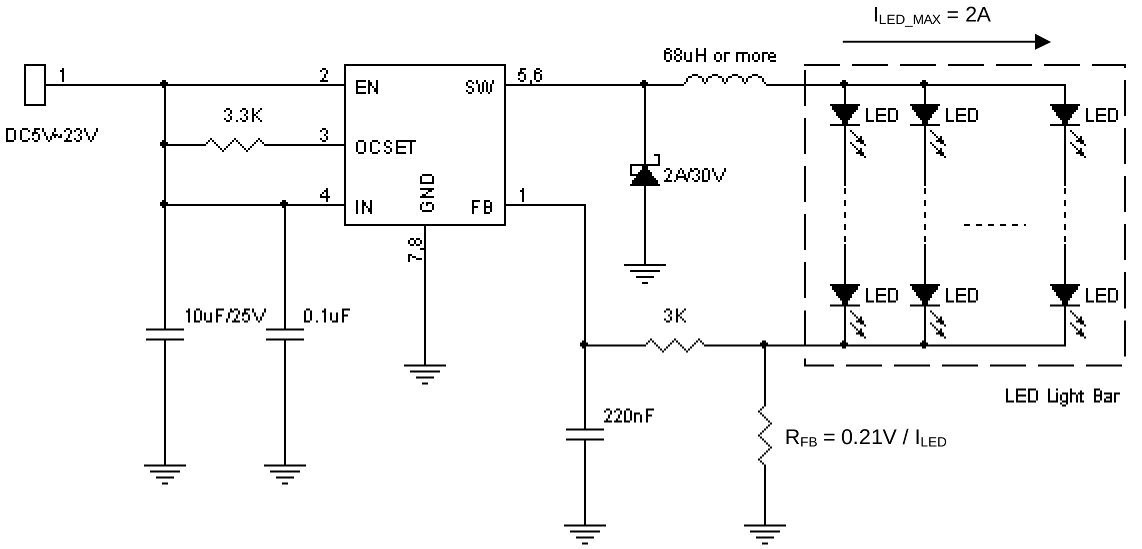
* Up to 10uF or more for Hot-Plugging Application
** For 1W LED: R_{FB} = 0.6Ohm 0805, I_{LED}=350mA
For 3W LED: R_{FB} = 0.3Ohm 1206, I_{LED}=700mA
For 5W LED: R_{FB} = 0.2Ohm 1206, I_{LED}=1050mA

♦ MR-16 Application: DC12V_{IN} or AC12V_{IN} for 1W LED x 3

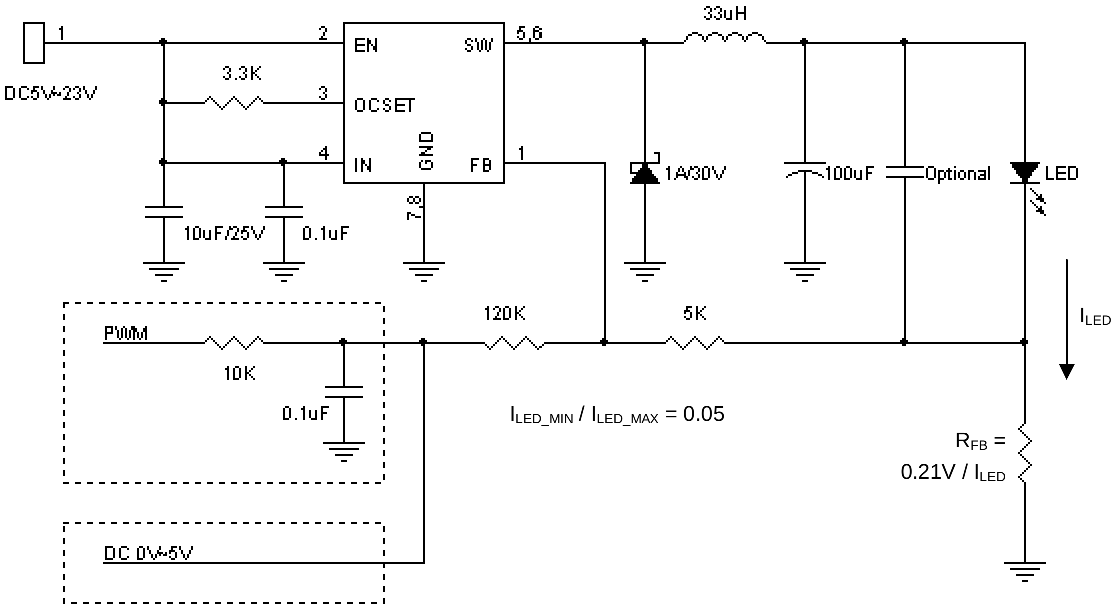


v Typical Application Circuits (Contd.)

◆ LED Light Bar Application

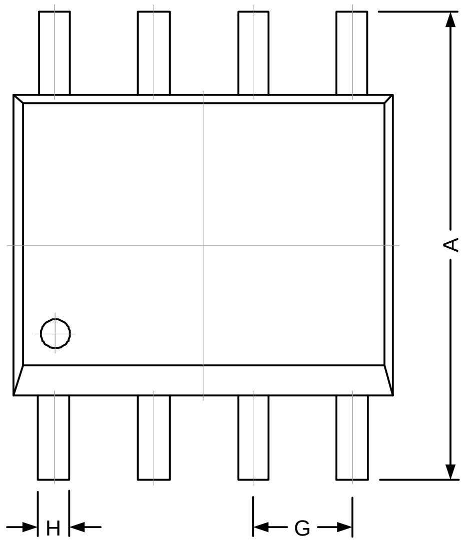


◆ LED Lighting Application with Dimming Control

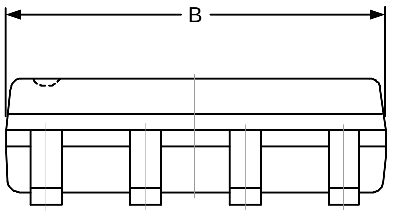


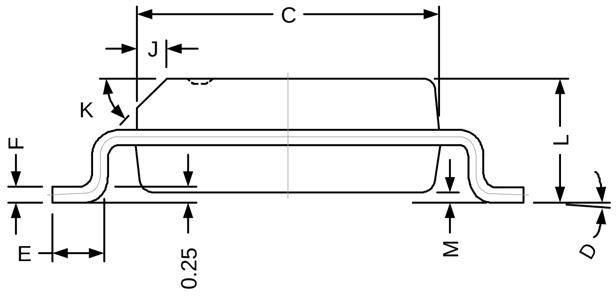
v Package Outline

SOP-8L



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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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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