DESCRIPTION

The A8180 is a continuous mode inductive step-down converter, designed for driving single or multiple series connected LEDs efficiently from a voltage source higher than the LED voltage. The device operates from an input supply between 6V and 40V and provides an externally output current up to 1.0A. Depending upon supply voltage and external components, this can provide up to 24 watts of output power.

The A8180 includes the output switch and a high-side output current sensing circuit, which uses an external resistor to set the nominal average output current.

Output current can be adjusted by applying an external control signal to the 'ADJ' pin. The ADJ pin will accept either a DC voltage or a PWM waveform. During DC dimming, this will provide a continuous output current that is proportional to the external applied DC voltage. During the PWM dimming, this will provide a gated output current, and the average current is proportional to the duty cycle. Applying a voltage of 0.2V or lower to the ADJ pin turns the output off and switches the device into a low current standby state.

The A8180 is available in SOT89-5 Package.

ORDERING INFORMATION

Package Type	Part Number	
SOT89-5 SPQ: 1,000pcs/Reel	K5	A8180K5R
		A8180K5VR
Note	V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products		

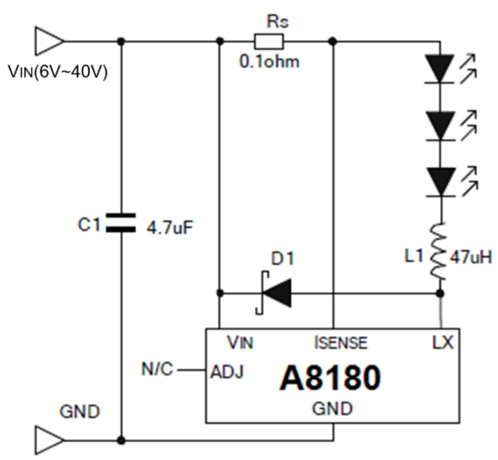
FEATURES

- Simple low parts count
- Internal 45V NDMOS switch
- Up to 1.0A output current
- Single pin on/off and brightness control using DC voltage or PWM
- Soft Start
- High efficiency (up to 97%)
- Wide input voltage range: 6V to 40V
- Output shutdown
- Up to 1MHz switching frequency
- Inherent open-circuit LED protection
- Typical 2% output current accuracy
- High-side current sense
- Hysteretic control: no compensation
- Adjustable constant LED current
- Over temperature protection
- Available in SOT89-5 package

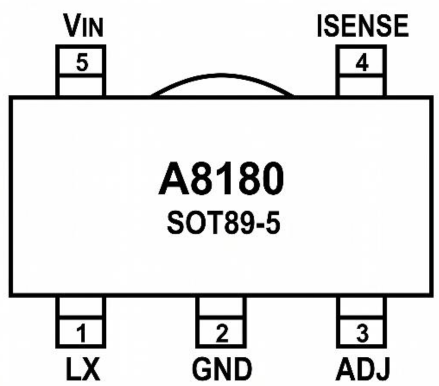
APPLICATIONS

- Low voltage halogen replacement LEDs
- Automotive lighting
- Low voltage industrial lighting
- LED back-up lighting
- Illuminated signs
- LCD TV backlighting

TYPICAL APPLICATION



PIN DESCRIPTION



Top View

Pin #	Symbol	Function
1	LX	Drain of NDMOS switch
2	GND	Ground (0V)
3	ADJ	Multi-function On/Off and brightness control pin: • Leave floating for normal operation. • Drive to voltage below 0.235V to turn off output current • Drive with DC voltage (0.235V < V_{ADJ} < 1.6V) to adjust output current from 20% to 100% of I_{OUTnom}. If the ADJ voltage is larger than 1.6V, the output current is 100 % I_{OUTnom}. • Drive with PWM signal from open-collector or open-drain transistor, to adjust output current. • Connect a capacitor from this pin to ground to activate soft start. (soft-start time is approx.0.06ms/nF)
4	I_{SENSE}	Connect resistor R_S from this pin to V_{IN} to define nominal average output current I_{OUTnom}=0.1/R_S (Note: If the ADJ pin is left floating, the minimum R_S value is 0.1Ω.)
5	V_{IN}	Input voltage (6V to 40V). Decouple to ground with 4.7uF or higher X7R ceramic capacitor close to device

ABSOLUTE MAXIMUM RATINGS

V_{IN}, Input Supply Voltage	-0.3V ~ +45V
V_{ISENSE}, I_{SENSE} Voltage	+0.3V ~ -5V(NOTE1)
V_{LX}, LX Output Voltage	-0.3V ~ +45V
V_{ADJ}, Adjust Pin Input Voltage	-0.3V ~+6V
I_{LX}, Switch Output Current	1.25A
$R_{\theta JA}$ Maximum Junction Temperature	140°C
Operating Temperature Range NOTE2	-40°C ~ 105°C
Storage Temperature Range	-55°C ~ 150°C
Lead Temperature (Soldering, 10s)	300°C
ESD (HBM)	4KV

Stresses above may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

NOTE1: V_{ISENSE} measured respect to V_{IN}.

NOTE2: The A8180 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the -40°C to 125°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

THERMAL RESISTANCE

Package	θ_{JA}	θ_{JC}
SOT89-5	160°C/W	45°C/W

NOTE: Thermal Resistance is specified with approximately 1 square of 1 oz copper.

ELECTRICAL CHARACTERISTICS

Test conditions: V_{IN} =12V, T_A = 25°C, unless otherwise noted

Parameter	Symbol	Conditions	Min	Typ.	Max	Units
Input voltage	V_{IN}		6		40	V
Under voltage lock out	V_{UVLO}	V_{IN} rising		5.8		V
UVLO hysteresis	$V_{UVLO(HYS)}$	V_{IN} falling		4.87		V
Quiescent supply current with output off	$I_{Q(OFF)}$	ADJ Pin grounded		120		μA
Quiescent supply current with output switching	$I_{Q(ON)}$	ADJ Pin floating f=250kHz		0.6	-	mA
Mean current sense threshold voltage	V_{ISENSE}	Measure on I_{SENSE} pin with respect to V_{IN}	96	100	104	mV
Sense threshold hysteresis	$V_{SENSE(HYS)}$			±15		%
I_{SENSE} pin input current	I_{SENSE}	$V_{ISENSE}=V_{IN}-0.1$		1.25	10	μA
Internal Voltage Reference	V_{REF}			1.2		V
Temperature Coefficient	$\Delta V_{REF}/\Delta T$				50	ppM
Analog Dimming Voltage Range	V_{ADJ}		0.235		1.6	V
DC voltage on ADJ pin to switch device from active (on) state to quiescent (off) state	$V_{ADJ(OFF)}$	V_{ADJ} falling	-	0.210	-	V
DC voltage on ADJ pin to switch device from quiescent (off) state to active (on) state	$V_{ADJ(ON)}$	V_{ADJ} rising	-	0.235	-	V
Continuous LX switch current	$I_{LX(MEAN)}$			-	1.0	A
LX switch on resistance	R_{LX}		-	0.4	--	Ω
LX switch leakage	$I_{LX(Leak)}$		-	-	1	μA
Duty cycle range of PWM signal applied to ADJ pin during low frequency PWM dimming mode	$D_{PWM(LF)}$	f_{ADJ}<500Hz V_{ADJ}=1.5V~5.5V	0.01		1	
				1000:1		
Minimum Power Switch ON Time	T_{ON-MIN}	LX=ON	200	-	-	ns
Minimum Power Switch OFF Time	$T_{OFF-MIN}$	LX=OFF	200	-	-	
Recommended maximum operating frequency	$f_{LX(MAX)}$				1.1	MHz
Recommended Duty Cycle at Maximum Operating Frequency	D_{LX}		0.3		0.7	
Internal Comparator Propagation Delay	T_{PD}			50		ns
Thermal Shutdown Threshold	T_{SD}			165		℃
Thermal Shutdown Hysteresis	T_{SD-HYS}			30		℃

TYPICAL PERFORMANCE CHARACTERISTICS

Test conditions: T_A = 25°C, L=47uH unless otherwise noted.

Fig1. Efficiency vs. Supply Voltage 1LED

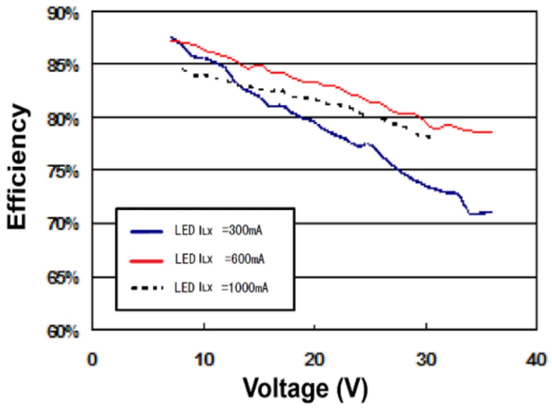


Fig 2. Output Current vs. Supply Voltage LED with 300mA

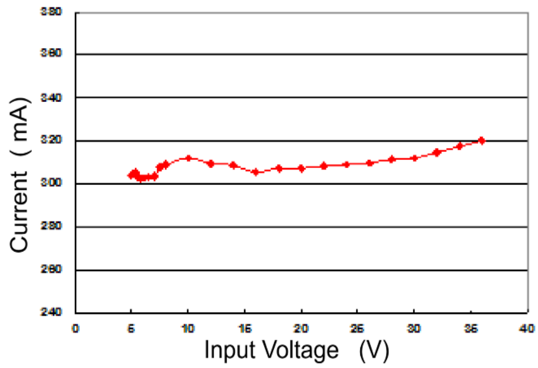


Fig 3. Efficiency vs. Supply Voltage 2LEDs

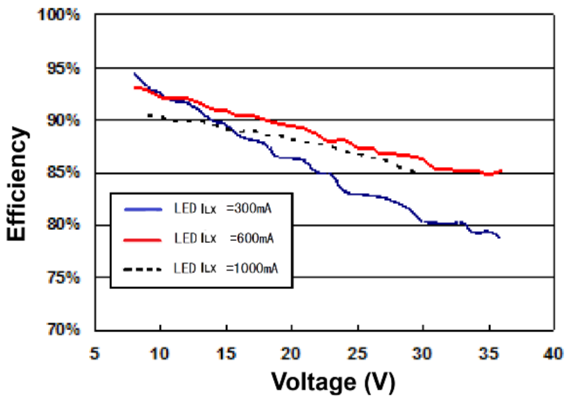


Fig 4. Output Current vs. Supply Voltage 2LEDs with 700mA

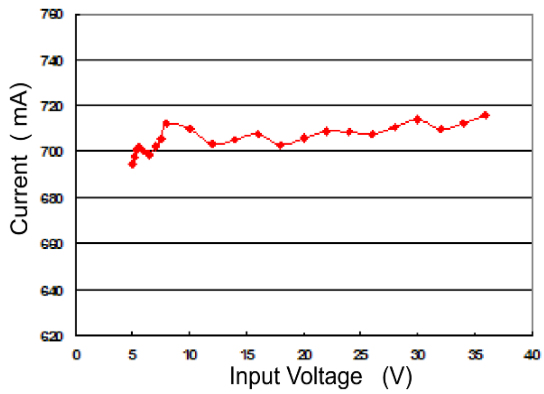


Fig 5. Efficiency vs. Supply Voltage 3LEDs

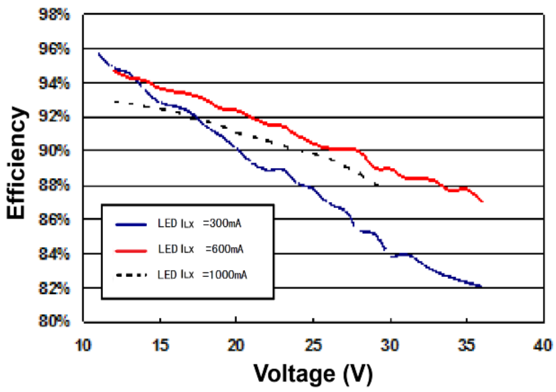


Fig 6. Output Current vs. Supply Voltage 3LEDs with700mA

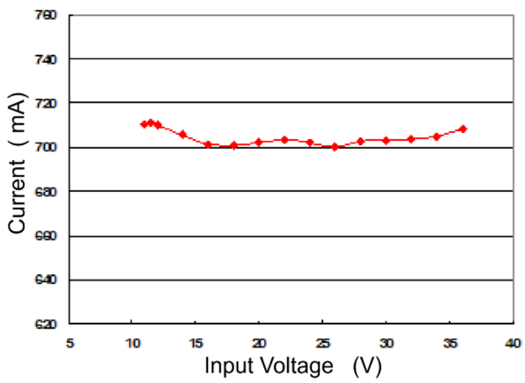


Fig 7. Current vs. Number of LEDs
LED current =300mA

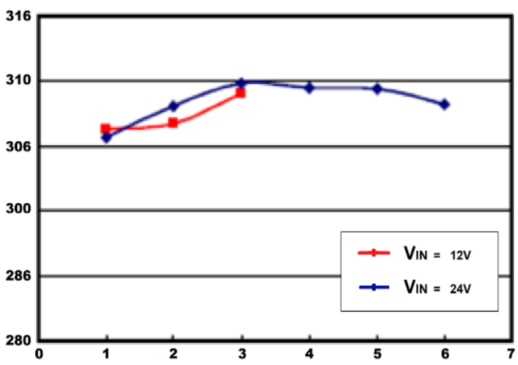


Fig 8. Current vs. Number of LEDs
LED current =600mA

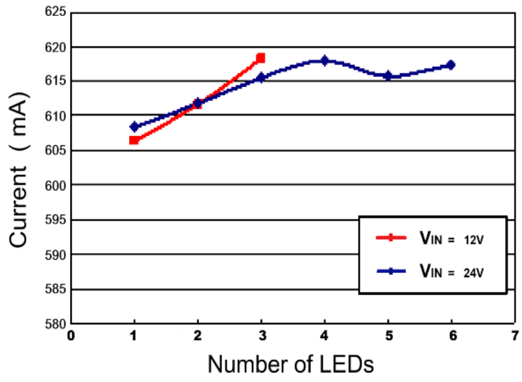


Fig 9. PWM Dimming Duty Cycle 500Hz
LED Current =600mA

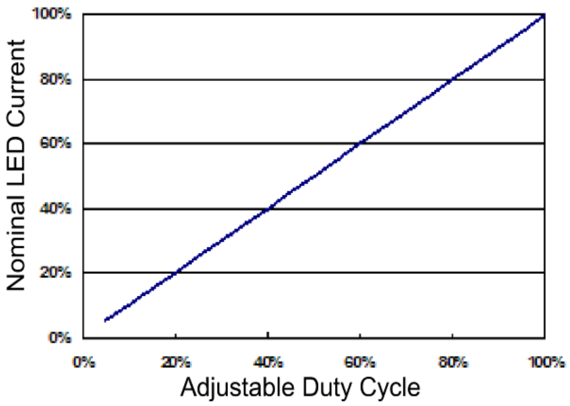


Fig 10. Analog Dimming LED current =600mA

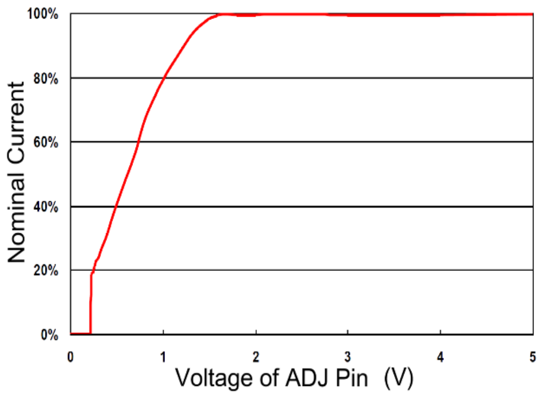
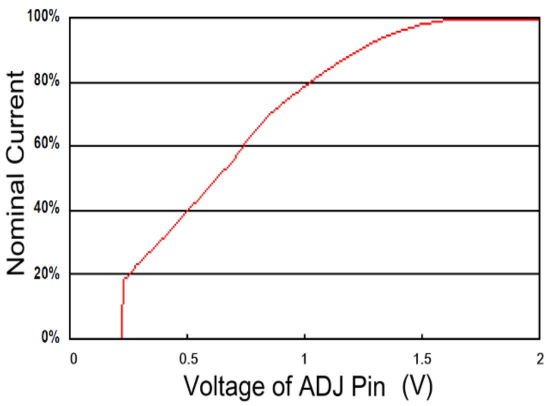
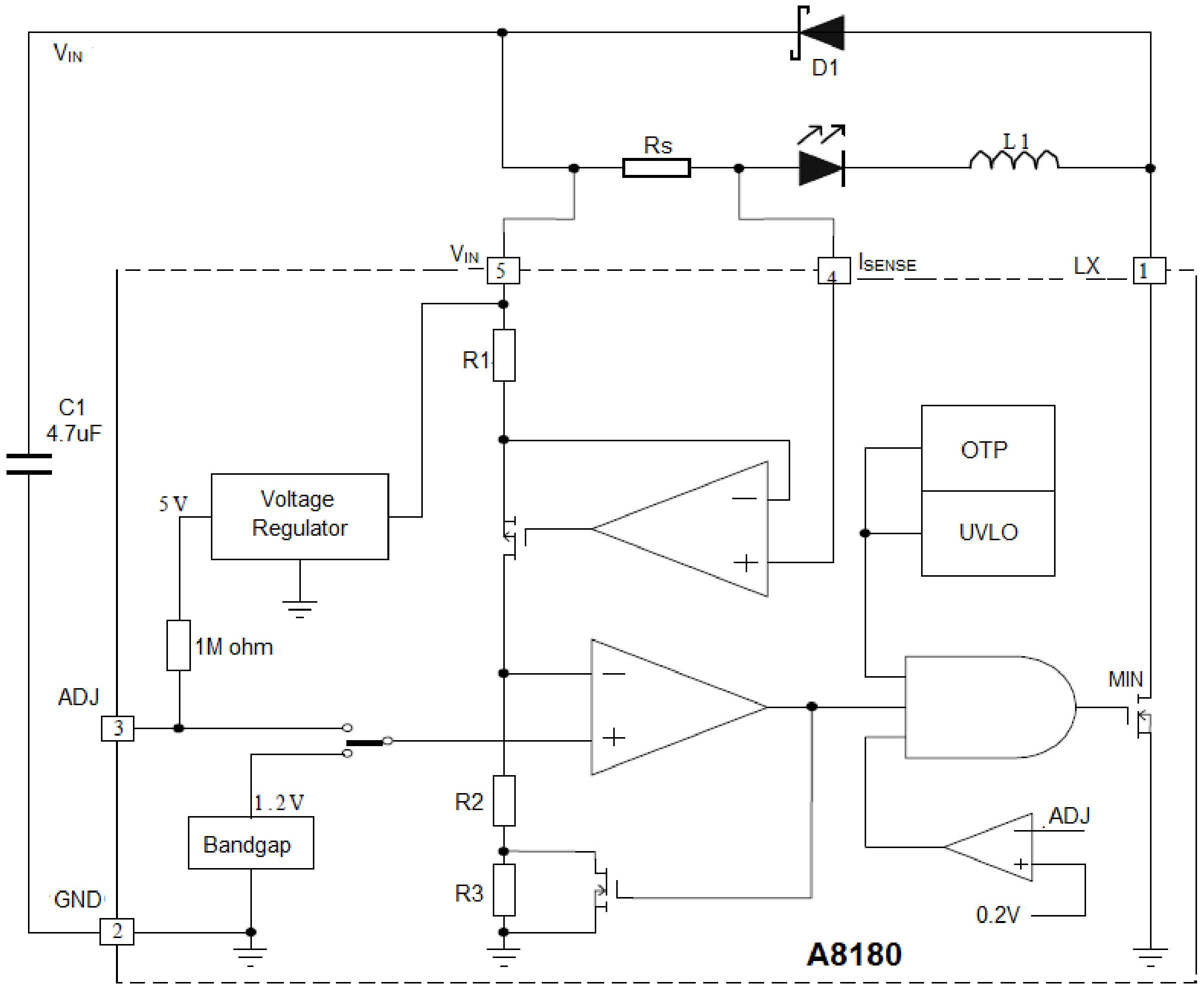


Fig 11. Analog Dimming (Zoom In) LED current =600mA



BLOCK DIAGRAM



DETAILED APPLICATION INFORMATION

Setting the Average LED Current with an External Current-Sense Resistor (R_S)

The average LED current is set by the external current-sense resistor (RS) connected between VIN and ISENSE. The nominal LED output current is determined by:

$I_{OUT(nom)} = 0.1 / RS$, for $RS > 0.1\ \Omega$

The following table provides typical examples of the relationship between the LED output current and the current-sense resistor (R_S).

R_S (Ω)	Output Average Current (mA)
0.1	1000
0.13	760
0.15	667

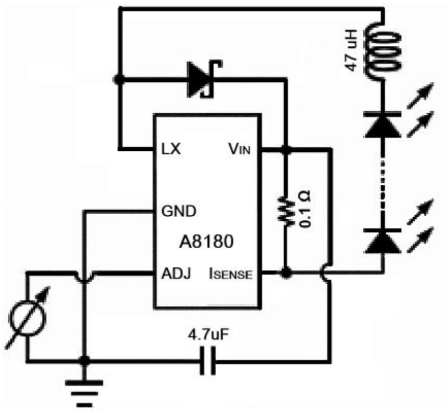
The above description applies when the ADJ pin is floating.

Note: The minimum allowable current-sense resistor value is $R_S = 0.1\ \Omega$, provided that the switch current remains below the specified maximum limit.

By applying an external voltage to the ADJ pin, the value of RS can be adjusted to set different LED output current levels.

Analog Dimming with a DC Voltage

Analog dimming can be achieved by applying an external DC voltage (V_{ADJ}) to the ADJ pin, as shown in the figure below. The external voltage adjusts the LED output current to a level below the nominal average current set by R_S.



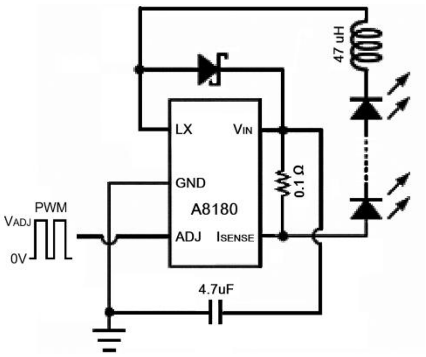
The DC voltage range for analog dimming is 0.235 V to 1.6 V. The nominal LED output current corresponding to the ADJ voltage is shown in the Analog Dimming Curve on the previous page.

Note: A 100% brightness setting corresponds to an LED output current of $0.1/R_S$.

When $V_{ADJ} > 1.6$ V, the internal circuitry of the A8180 limits the brightness to 100%.

PWM Dimming

A pulse-width modulation (PWM) signal with a duty cycle of DPWM can be applied to the ADJ pin to control the LED output current, as shown in the figure below. By adjusting the PWM duty cycle, the LED output current can be adjusted to a level below the average current set by RS.



The amplitude of the PWM signal must be greater than 2.0 V and is typically maintained between 3.0 V and 5.0 V. For optimal PWM dimming performance, the PWM signal frequency should be maintained between 100 Hz and 2 kHz.

Shutdown Mode

When the voltage at the ADJ pin remains below 0.21 V for 100 µs or longer, the system automatically enters shutdown mode. The system quiescent current is maintained below 120 µA in shutdown mode.

Built-In LED Open-Circuit Protection

If an open-circuit condition occurs in the LED load, the inductor connected to the LX pin is disconnected from the circuit, preventing current from flowing through the loop and protecting the device from damage. This protection also prevents the back EMF from continuously increasing in boost converter applications, which could otherwise cause breakdown of the internal power switch.

Capacitor Selection

A low-ESR bypass capacitor should be placed as close as possible to the power input pin. A higher ESR results in greater power loss and reduced efficiency. The bypass capacitor must be capable of handling the peak input current while smoothing the input current and reducing the impact on the input power supply. For a DC input, the minimum recommended bypass capacitance is 4.7 µF. Under low-input-voltage conditions or when the input power supply has relatively high impedance, a larger capacitance may provide better performance. The bypass capacitor should be placed as close as possible to the IC input pin to minimize parasitic impedance.

Inductor Selection

The recommended inductance range for the A8180 is 27 μH to 100 μH. At higher input voltages, a larger inductance value is recommended to reduce errors caused by switch delays. These errors can increase inductor ripple current and reduce efficiency.

A larger inductance also reduces the variation in LED output current over a wider input-voltage range.

The inductor should be placed as close as possible to the VIN and LX pins to minimize efficiency losses caused by parasitic resistance and to reduce radiated electromagnetic interference (EMI).

The inductor saturation current rating should be higher than the peak inductor current, and the nominal current rating should be higher than the average output current.

Inductor selection must take the operating duty cycle and the turn-on and turn-off times of the power switch into consideration to ensure proper operation over the full input-voltage and LED-current ranges.

The following equations can be used as a reference.

a. Power Switch On-Time

$$T_{ON} = L \times \Delta I / [V_{IN} - V_{LED} - I_{LED(avg)} \times (R_S + r_L + R_{LX})]$$

Note: $T_{ON(min)} > 200$ ns

b. Power Switch Off-Time

$$T_{OFF} = L \times \Delta I / [V_D + V_{LED} + I_{LED(avg)} \times (R_S + r_L)]$$

Note: $T_{OFF(min)} > 200$ ns

Parameter Definitions

Symbol	Parameter	Unit
L	Inductance	H
r_L	Inductor Parasitic Resistance	Ω
$I_{LED(avg)}$	Average LED Current	A
ΔI	Peak-to-Peak Inductor Current Ripple Internally Set to 0.3 × IAVG	A
V_{IN}	Supply Voltage	V
V_{LED}	Total LED Forward Voltage	V
R_{LX}	Power Switch On-Resistance	Ω
V_D	Schottky Diode Forward Voltage	V

Diode Selection

The peak current rating of the diode should be higher than the peak inductor current, and the rated current should be higher than the maximum LED output current.

The reverse leakage current of the Schottky diode should also be considered at temperatures above 85°C. Excessive reverse leakage current can increase system power consumption.

Reducing Output Ripple

One of the most effective methods for reducing the peak-to-peak current LED ripple is to connect a capacitor in parallel with the LED load. A 1-μF capacitor can reduce the output ripple by approximately one-third. Increasing the parallel capacitance can further suppress the output ripple. The output capacitor does not affect the operating frequency or efficiency of the system, but it does affect the startup delay and the rise time of the inductor current.

Low-Input-Voltage Considerations

When the input voltage is below the minimum startup voltage (V_{SU}), the internal power switch remains off until the input voltage rises above V_{SU}. When the input voltage is close to or below the specified minimum operating voltage, the switch duty cycle may become relatively large, resulting in increased IC power dissipation. In practical applications, such operating conditions should be avoided to ensure that the IC junction temperature remains below the specified maximum limit. When the LED load consists of two or more LEDs, the required input voltage may be higher than the IC's specified minimum 6V operating voltage. This condition reduces the risk of excessive IC power dissipation and potential device damage.

LAYOUT CONSIDERATION

Careful PCB layout is critical to achieve low switching losses and stable operation. Use a multilayer board whenever possible for better noise immunity. Minimize ground noise by connecting high-current ground returns, the input bypass-capacitor ground lead, and the output-filter ground lead to a single point (star ground configuration).

LX Pin

The LX pin of the device is a fast-switching node, so PCB tracks should be kept as short as possible. To minimize ground 'bounce', the ground pin of the device should be soldered directly to the ground plane.

Coil and Decoupling Capacitors and Current Sense Resistor

It is particularly important to mount the coil and the input decoupling capacitor as close to the device pins as possible to minimize parasitic resistance and inductance, which will degrade efficiency. It is also important to minimize any track resistance in series with current sense resistor R_S. It's best to connect V_{IN} directly to one end of R_S and I_{SENSE} directly to the opposite end of R_S with no other currents flowing in these tracks. It is important that the cathode current of the Schottky diode does not flow in a track between R_S and V_{IN} as this may give an apparently higher measure of current than is actually because of track resistance.

ADJ Pin

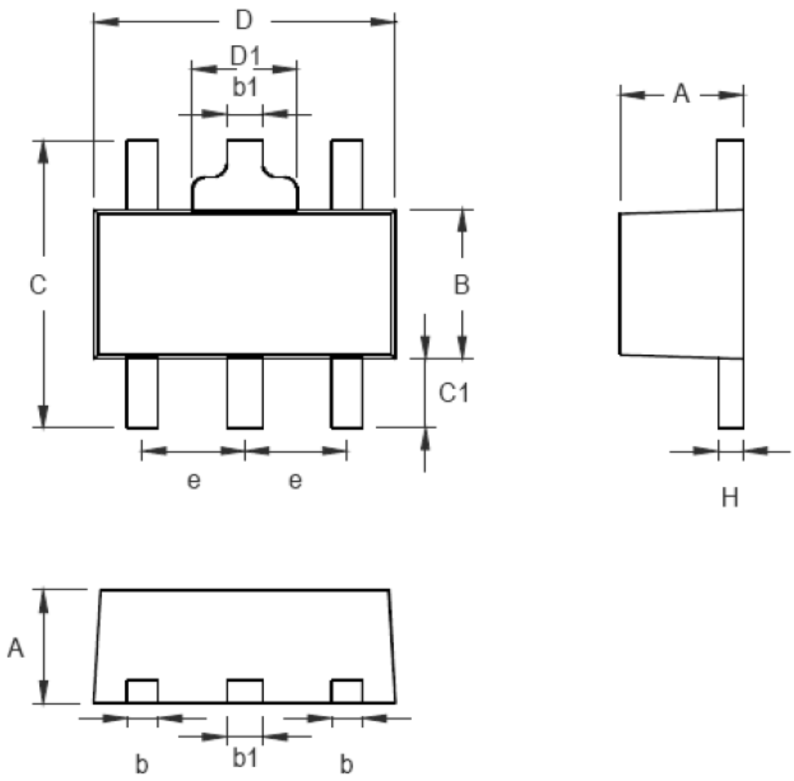
The ADJ pin is a high impedance input, so when left floating, PCB traces to this pin should be as short as possible to reduce noise pickup. ADJ pin can also be connected to a voltage between 1.2V~5V. In this case, the internal circuit will clamp the output current at the value which is set by ADJ=1.2V.

High Voltage Traces

Avoid running any high voltage traces close to the ADJ pin, to reduce the risk of leakage due to board contamination. Any such leakage may raise the ADJ pin voltage and cause excessive output current. A ground ring placed around the ADJ pin will minimize changes in output current under these conditions.

PACKAGE INFORMATION

Dimension in SOT89-5 (Unit: mm)



<table>
<tr><th rowspan="2">Symbol</th><th colspan="2">MILLIMETERS</th></tr>
<tr><th>Min</th><th>Max</th></tr>
<tr><td>A</td><td>1.400</td><td>1.600</td></tr>
<tr><td>b</td><td>0.320</td><td>0.520</td></tr>
<tr><td>b1</td><td>0.360</td><td>0.560</td></tr>
<tr><td>B</td><td>2.300</td><td>2.600</td></tr>
<tr><td>C</td><td>3.940</td><td>4.250</td></tr>
<tr><td>C1</td><td>0.900</td><td>1.100</td></tr>
<tr><td>D</td><td>4.400</td><td>4.600</td></tr>
<tr><td>D1</td><td>1.400</td><td>1.800</td></tr>
<tr><td>e</td><td colspan="2">1.500 TYP</td></tr>
<tr><td>H</td><td>0.350</td><td>0.440</td></tr>
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