GENERAL DESCRIPTION

The PT4211B is a continuous conduction mode inductive step-down converter, designed for driving single or multiple series connected LEDs from a voltage source higher than the LED voltage. The device operates from an input supply between 5V and 36V and provides an externally adjustable output current of up to 600mA.

The PT4211B includes the output switch and a high-side output current sensing circuit, which uses an external resistor to set the nominal average output current, and a dedicated DIM input accepts a wide range of pulsed dimming. Applying a low voltage to the DIM pin turns the output off and switches the device into a low current standby state. Built-in Over Temperature Protection protects the device from over temperature damage.

The PT4211B is available in SOT23-5 package.

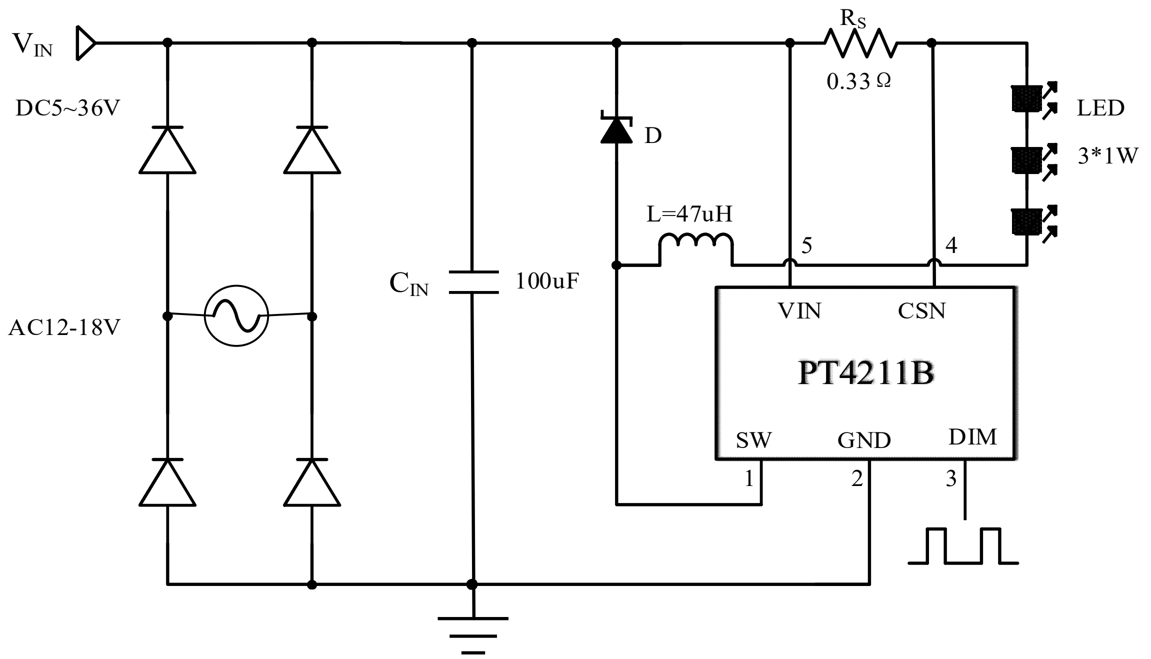
FEATURES

- Simple low parts count
- Wide input voltage range: 5V to 36V
- Up to 600mA output current
- Single pin on/off and brightness control using DC voltage or PWM
- 3% output current accuracy.
- Typical 3% output current accuracy
- Inherent open-circuit LED protection
- High efficiency (up to 93%)
- Adjustable Constant LED Current
- High-Side Current Sense
- Over Temperature Protection

APPLICATIONS

- Low voltage halogen replacement LEDs
- Automotive lighting
- LED back-up lighting
- Illuminated signs

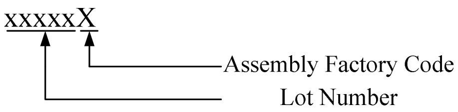
TYPICAL APPLICATION CIRCUIT



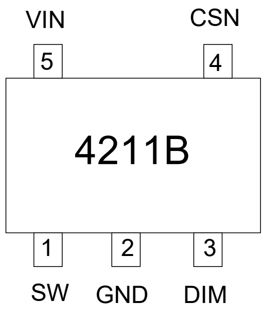
ORDERING INFORMATION

PACKAGE	ORDERING PART NUMBER	TRANSPORT MEDIA	MARKING
SOT23-5	PT4211BE23E	Tape and Reel 3000 units	4211B

Note:



PIN ASSIGNMENT



SOT23-5

PIN DESCRIPTIONS

PIN No.	PIN NAMES	DESCRIPTION
1	SW	Switch Output. SW is the drain of the internal N-Ch MOSFET switch.
2	GND	Signal and power ground. Connect directly to ground plane.
3	DIM	Logic level dimming input. Drive DIM low to turn off the current regulator. Drive DIM high to enable the current regulator.
4	CSN	Current sense input
5	VIN	Input Supply Pin. Must be locally bypassed.

ABSOLUTE MAXIMUM RATINGS (Note1)

SYMBOL	PARAMETER	VALUE	UNIT
V_{IN}	Supply Voltage	-0.3~40	V
SW	Drain of the internal power switch	-0.3~40	V
CSN	Current sense input (Respect to VIN)	+0.3~(-6.0)	V
DIM	Logic level dimming input	-0.3~6	V
I_{SW}	Switch output current	800	mA
P_{DMAX}	Power Dissipation (Note 2)	260	mW
P_{TR}	Thermal Resistance, SOT23-5 θ_{JA}	250	ºC /W
T_J	Operation Junction Temperature Range	-40 to 150	ºC
T_{STG}	Storage Temperature	-55 to 150	ºC
	ESD	2	kV

RECOMMENDED OPERATING RANGE

SYMBOL	PARAMETER	VALUE	UNIT
Iout	Output Current	≤600	mA

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Recommended Operating Range indicates conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Range. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 2: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{JMAX}, θ_{JA}, and the ambient temperature T_A. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX} - T_A)/ \theta_{JA}$ or the number given in Absolute Maximum Ratings, whichever is lower.

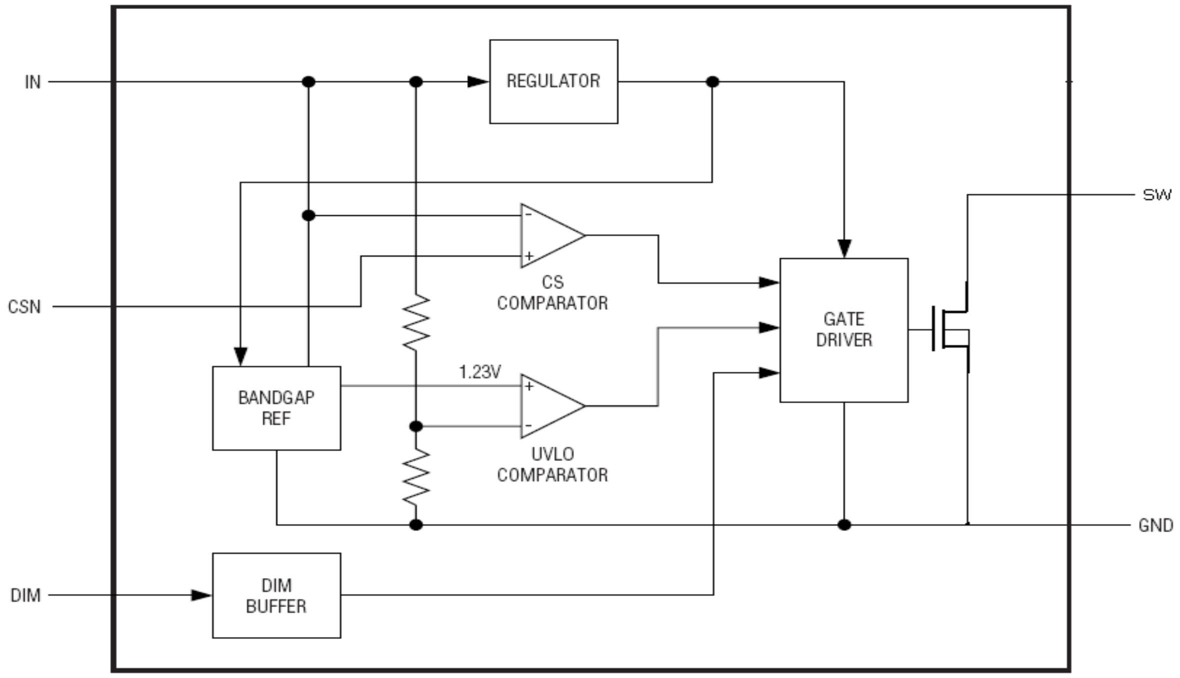
ELECTRICAL CHARACTERISTICS (Note 3, 4)

The following specifications apply for V_{IN}=12V, T_A=25 °C, unless specified otherwise.

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Input Voltage						
V_{IN}	VIN supply voltage		5		36	V
I_{OFF}	Off state operating current	V_{DIM}<0.25V		95		μA
operating frequency						
F_{SW}	Maximum operating frequency				1	MHz
Current sense						
V_{CSN}	Current sense Reference voltage	V_{IN}- V_{CSN}	194	200	206	mV
V_{CSN_hys}	Current sense Hysteretic voltage			±15		%
I_{CSN}	CSN pin bias current	V_{IN}-V_{CSN}=50mV		8		μA
DIM input						
V_{DIM}	DIM pin floating voltage	DIM floating		4.5		V
V_{DIM_PWMH}	DIM input logic high		2.5			V
V_{DIM_PWML}	DIM input logic low				0.2	V
V_{DIM_DC}	DC brightness control		0.5		2.5	V
f_{DIM}（note 5）	Maximum dimming frequency	f_{OSC}=500kHz			20	kHz
R_{DIM}	DIM pin internal pull up resistance			200		KΩ
I_{DIM_L}	DIM pin short to GND current	V_{DIM} = 0		22		uA
Output Switch						
R_{SW}	SW on stage resistance			0.5		Ω
I_{SWmean}	SW maximum current				600	mA
I_{LEAK}	SW leakage current	Vsw=36V，SW off		0.5	5	μA
Thermal Shutdown						
T_{SC}	Thermal Regulation Temperature			135		℃

Note 3: Typical parameters are measured at 25˚C and represent the parametric norm.
Note 4: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.
Note 5: The maximum dimming frequency is limited by operating frequency because operating frequency varies with supply voltage, output voltage and inductor selection, to achieve the best dimming linearity, the dimming frequency is recommended to limited less than 1% of operating frequency.

SIMPLIFIED BLOCK DIAGRAM



OPERATION DESCRIPTION

The device, in conjunction with the coil (L) and current sense resistor (Rs), forms a self oscillating continuous-mode buck converter.

When input voltage VIN is first applied, the initial current in L and Rs is zero and there is no output from the current sense circuit. Under this condition, the output of CS comparator is high. This turns on the internal switch and switches the SW pin low, causing current to flow from VIN to ground, via Rs, L and the LED(s). The current rises at a rate determined by VIN and L to produce a voltage ramp (V_{CSN}) across Rs. When (V_{IN}-V_{CSN}) > 230mV, the output of CS comparator switches low and the switch turns off. The current flowing on the Rs decreases at another rate. When (V_{IN}-V_{CSN}) < 170mV, the switch turns on again and the mean current on the LED is determined by

$$I_{OUT} = 0.2 / Rs\,.$$

The PT4211B allows dimming with a PWM signal at the DIM input. A logic level below V_{DIM_PWML} at DIM forces PT4211B to turn off and the logic level at DIM higher than V_{DIM_PWMH} to turn the device on. The frequency of PWM dimming ranges from 100Hz to 20 kHz.

The DIM pin is pulled up to the internal V_{DIM} by a resistor when it is floating. When a voltage applied to DIM is low, the switch is turned off. The internal regulator and voltage reference remain powered during shutdown to provide the reference for the shutdown circuit. Quiescent supply current during shutdown is nominally I_{OFF} .

Additionally, to ensure the reliability, the PT4211B is built with an over temperature protection. If the junction temperature exceeds TSC, the device will reduce output current to avoid system cause to damage.

APPLICATION NOTES

Setting nominal average output current with external resistor R_S

The nominal average output current in the LED(s) is determined by the value of the external current sense resistor (R_S) connected between VIN and CSN and is given by:

$$I_{OUT} = 0.2/R_S$$

This equation is valid when DIM pin is float or applied with a voltage higher than V_{DIM_PWMH} (must be less than 5V). Actually, R_S sets the maximum average current which can be adjusted to a less one by dimming.

Inductor selection

Recommended inductor values for the PT4211B are in the range 47uH to 100uH.
Higher values of inductance are recommended at lower output current in order to minimize errors due to switching delays, which result in increased ripple and lower efficiency. Higher values of inductance also result in a smaller change in output current over the supply voltage range. (See graphs). The inductor should be mounted as close to the device as possible with low resistance connections to the SW and VIN pins.
The chosen coil should have a saturation current higher than the peak output current and a continuous current rating above the required mean output current.
Following table gives the guideline on inductor selection:

Vin	1LED	2LEDs	3LEDs	Saturation current
5V-10V	47uH	68uH		1.3-1.5 times of load current
10V-20V	68uH	68uH	47uH	
20V-36V	100uH	68uH	47uH	

The inductor value should be chosen to maintain operating duty cycle and switch 'on'/'off' times within the specified limits over the supply voltage and load current range.
The following equations can be used as a guide.

SW Switch 'On' time

$$T_{ON} = \frac{L \times \Delta I}{V_{IN} - V_{LED}}$$

SW Switch 'Off' time

$$T_{OFF} = \frac{L \times \Delta I}{V_{LED} + V_D}$$

Where:

L	the coil inductance	(H)
Iavg	the required LED current	(A)
ΔI	the coil peak-peak ripple current	(A) {set with 0.3 x Iavg}
V_{IN}	supply voltage	(V)
V_{LED}	total LED forward voltage	(V)
V_D	he diode forward voltage at the required load current	(V)

Diode selection

For maximum efficiency and performance, the rectifier (D) should be a fast low capacitance Schottky diode with low reverse leakage at the maximum operating voltage and temperature.
They also provide better efficiency than silicon diodes, due to a combination of lower forward voltage and reduced recovery time.
It is important to select parts with a peak current rating above the peak coil current and a continuous current rating higher than the maximum output load current. It is very important to consider the reverse leakage of the diode when operating above 85°C. Excess leakage will increase the power dissipation in the device and if close to the load may create a thermal runaway condition.
The higher forward voltage and overshoot due to reverse recovery time in silicon diodes will increase the peak voltage on the SW output. If a silicon diode is used, care should be taken to ensure that the total voltage appearing on the SW pin including supply ripple, does not exceed the specified maximum value.

Thermal shutdown protection

To ensure the reliability, the PT4211B is built with an over temperature protection. When junction temperature excess 135℃, the device will reduce output current to avoid system cause to damage.

Layout considerations

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).

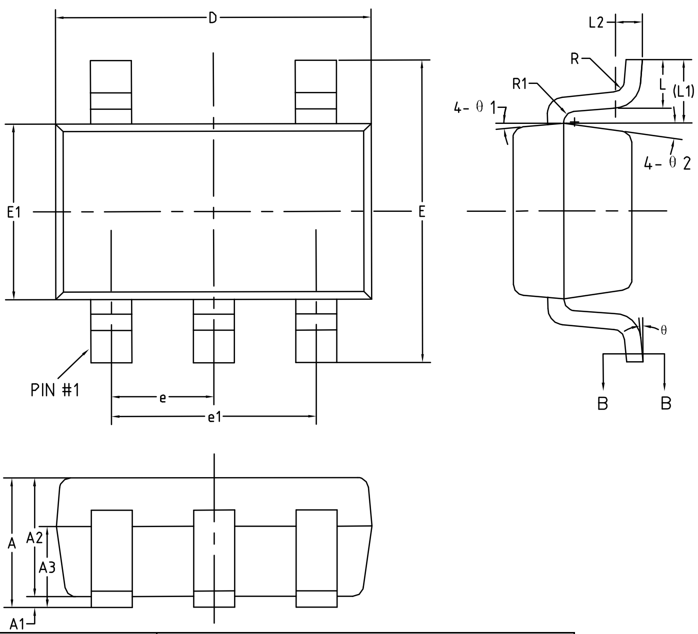
SW pin

The SW 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

PACKAGE INFORMATION

SOT23-5



SYMBOL	MILLIMETERS		
	MIN	TYP	MAX
A	-	-	1.25
A1	0	-	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.36	-	0.50
b1	0.36	0.38	0.45
c	0.14	-	0.20
c1	0.14	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.726
e	0.95BSC		
e1	1.90BSC		
L	0.35	0.45	0.60
L1	0.59REF		
L2	0.25BSC		
R	0.10	-	-
R1	0.10	-	0.25
θ	0°	-	8°
θ1	3°	5°	7°
θ2	6°	8°	10°

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