

### Description

The BP3211 is a high efficiency TRIAC dimmable LED driver. The device operates in critical conduction mode and is suitable for buck, buck-boost or fly-back LED lighting.

The BP3211 integrates a 300V power MOSFET. It utilizes patent pending MOSFET driving technique and current sensing method. The operating current of the IC is very low. With very few external components count, it can achieve excellent constant current performance, so the system cost and size are greatly reduced.

The BP3211 offers rich protection functions to improve the system reliability, including LED open circuit protection, LED short circuit protection, VCC under voltage protection, CS resistor short circuit protection and thermal regulation function.

The BP3211 is available in a SOP8 Package.

### Features

- TRIAC dimmable
- Internal 300V Power MOSFET
- Critical Conduction Mode Operation
- Ultra Low Operating Current
- $\pm 5\%$  LED Output Current Accuracy
- LED Open Protection
- LED Short Protection
- Current Sensing Resistor Short Protection
- VCC Under Voltage Protection
- Thermal Regulation Function
- Available in SOP8 Package

### Applications

- LED Candle Light
- LED Bulb
- Other LED Lighting

### Typical Application

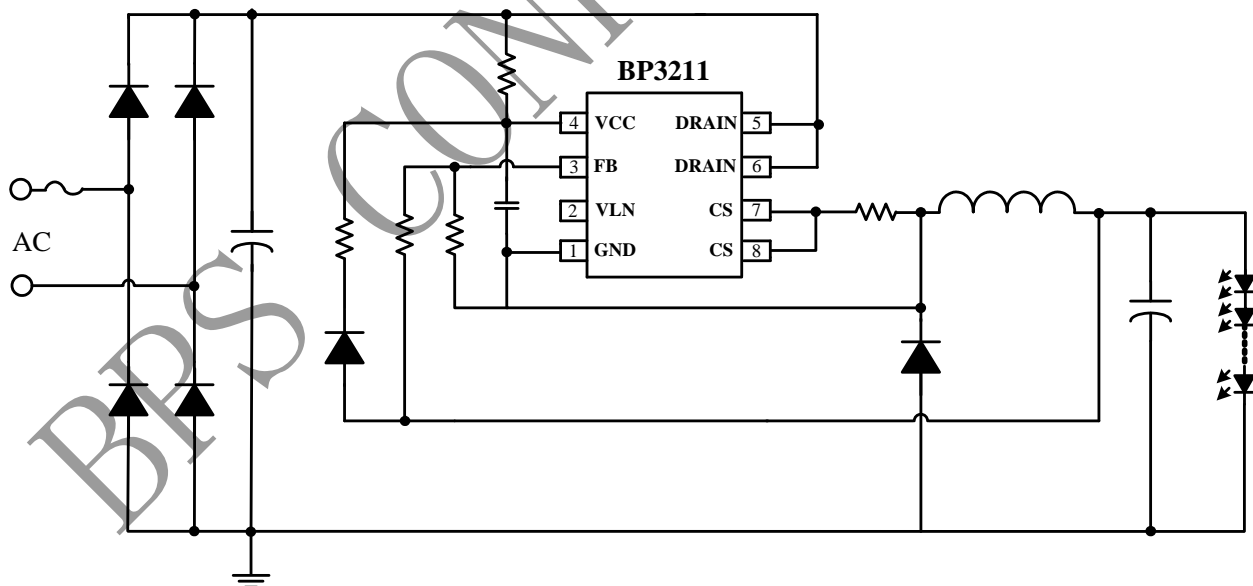


Figure 1. Typical application circuit for BP3211 (Buck)

### Ordering Information

Part Number	Package	Operating Temperature	Packing Method	Marking
BP3211	SOP8	-40 °C to 105 °C	Tape 4,000 Piece/Roll	BP3211 XXXXXY WWXY

### Pin Configuration and Marking Information

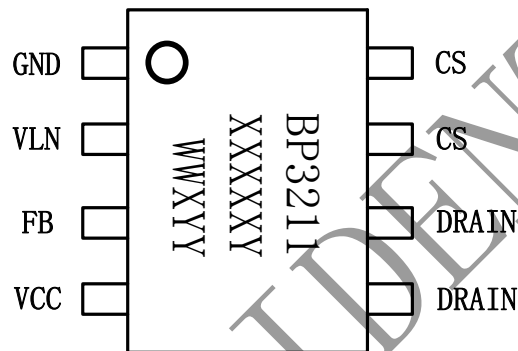


Figure 2. Pin configuration

### Pin Definition

Pin No.	Name	Description
1	GND	Ground
2	VLN	Line Voltage Detecting Pin
3	FB	Over Voltage Protection Detecting Pin.
4	VCC	Power Supply Pin
5, 6	DRAIN	Internal HV Power MOSFET Drain.
7, 8	CS	Current Sense Pin. Connect a sensing resistor between this pin and GND pin.

**Absolute Maximum Ratings (note 1)**

Symbol	Parameters	Range	Units
ICC_MAX	VCC pin maximum sink current	10	mA
DRAIN	Internal HV MOSFET drain voltage	-0.3~300	V
CS	Current sense pin input voltage	-0.3~6	V
FB	Over voltage protection detecting pin voltage	-0.3~6	V
VLN	Line voltage detecting pin voltage	-0.3~6	V
P_DMAX	Power dissipation (note 2)	0.45	W
$\theta_{JA}$	Thermal resistance (Junction to Ambient)	145	°C/W
T <sub>J</sub>	Operating junction temperature	-40 to 150	°C
T <sub>STG</sub>	Storage temperature range	-55 to 150	°C
	ESD (note 3)	2	KV

**Note 1:** Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. Under “recommended operating conditions” the device operation is assured, but some particular parameter may not be achieved. The electrical characteristics table defines the operation range of the device, the electrical characteristics is assured on DC and AC voltage by test program. For the parameters without minimum and maximum value in the EC table, the typical value defines the operation range, the accuracy is not guaranteed by spec.

**Note 2:** The maximum power dissipation decrease if temperature rise, it is decided by  $T_{JMAX}$ ,  $\theta_{JA}$ , and environment temperature ( $T_A$ ). The maximum power dissipation is the lower one between  $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$  and the number listed in the maximum table.

**Note 3:** Human Body mode, 100pF capacitor discharge on 1.5K $\Omega$  resistor

**Electrical Characteristics (Notes 4, 5) (Unless otherwise specified,  $V_{CC}=15V$  and  $T_A=25^\circ C$ )**

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>Supply Voltage Section</b>						
$V_{CC\_CLAMP}$	$V_{CC}$ Clamp Voltage	1mA		18.8		V
$V_{CC\_ON}$	$V_{CC}$ Turn On Threshold	$V_{CC}$ Rising		14		V
$V_{CC\_UVLO}$	$V_{CC}$ Turn off Threshold	$V_{CC}$ Falling		8.8		V
$I_{ST}$	$V_{CC}$ Startup Current	$V_{CC}=V_{CC\_ON}-1V$		120	180	uA
$I_{OP}$	$V_{CC}$ Operating Current	$F_{OP}=70KHz$		150	250	uA
<b>Current Sense Section</b>						
$V_{CS\_TH}$	Threshold Voltage for Peak Current Limit		380	400	420	mV
$V_{CS\_SHORT}$	Threshold Voltage for Peak Current Limit When Output Short	Output Short		200		mV
$T_{LEB}$	Leading Edge Blanking Time for Current Sense			350		ns
$T_{DELAY}$	Switch Off Delay Time			200		ns
$V_{VLN\_TH}$	Line Voltage Feed Forward Threshold			3		V
<b>Internal Time Control Section</b>						
$T_{OFF\_MIN}$	Minimum OFF Time			2.5		us
$T_{OFF\_MAX}$	Maximum OFF Time			250		us
$T_{ON\_MAX}$	Maximum On Time			9.5		us
<b>Over Voltage Protection Section</b>						
$V_{FB\_OVP}$	FB Over Voltage Protection Threshold			1		V
<b>MOSFET Section</b>						
$R_{DS\_ON}$	Static Drain-source On-resistance	$V_{GS}=15V/I_{DS}=0.5A$		3		$\Omega$
$BV_{DSS}$	Drain-Source Breakdown Voltage	$V_{GS}=0V/I_{DS}=250uA$	300			V
$I_{DSS}$	Power MOSFET Drain Leakage Current	$V_{GS}=0V/V_{DS}=300V$			1	uA
<b>过热调节</b>						
$T_{REG}$	Thermal Regulation Temperature			150		$^\circ C$

Note 4: production testing of the chip is performed at 25 °C.

Note 5: the maximum and minimum parameters specified are guaranteed by test, the typical value are guaranteed by design, characterization and statistical analysis

### Internal Block Diagram

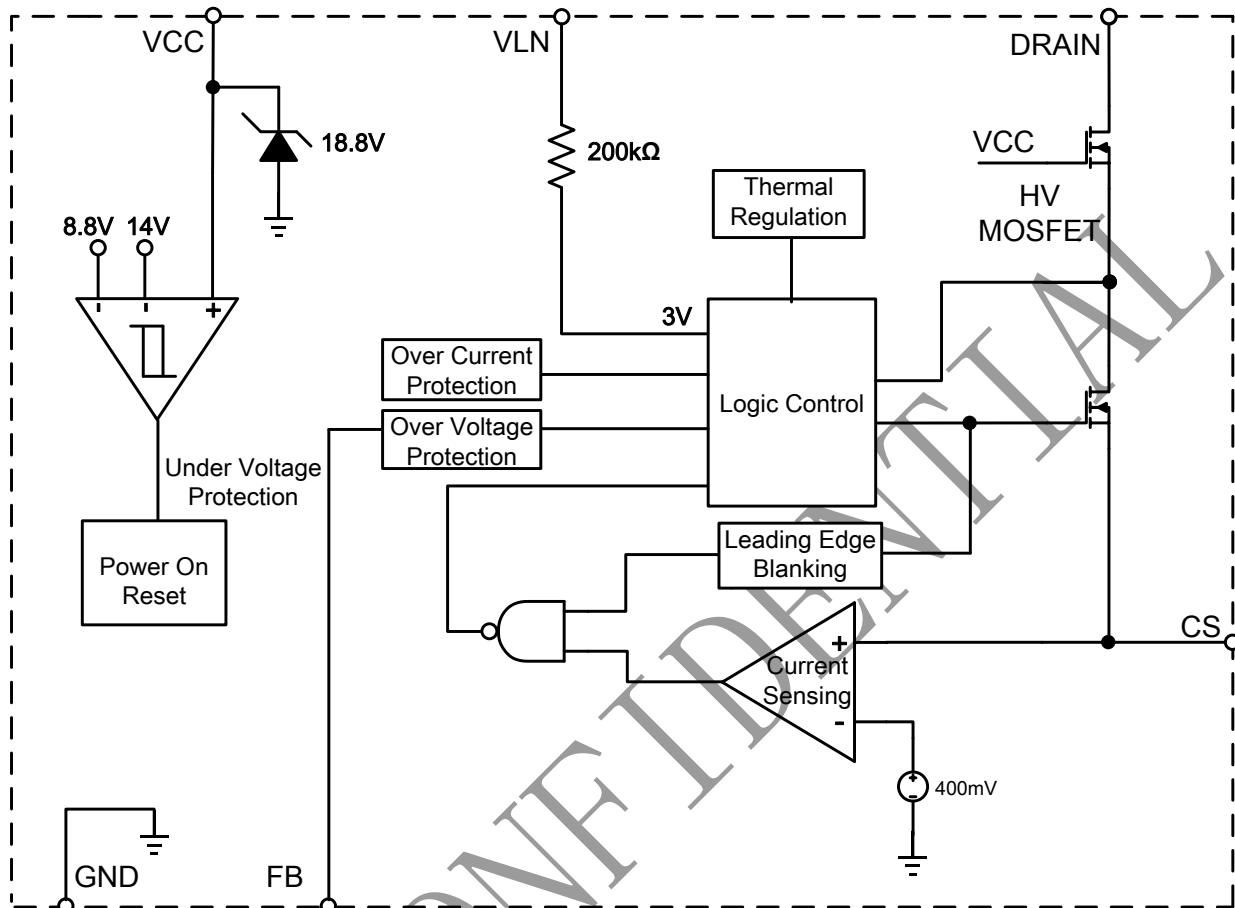


Figure 3. BP3211 Internal Block Diagram

### Application Information

The BP3211 is a high efficiency TRIAC dimmable LED driver IC, specially designed for Buck, Buck-boost or Fly-back LED lighting. The BP3211 integrates a 300V power MOSFET. Utilizing patent pending MOSFET source driving technique, it can achieve excellent constant current performance with very few external components count, so the system cost and size are greatly reduced.

#### Start Up

After system powered up, the VCC pin capacitor is charged up by the start up resistor. When the VCC pin voltage reaches the turn on threshold, the internal circuits start operating. The BP3211 integrates an 18.8V zener diode to clamp the VCC voltage. After

the output voltage is established, VCC is supplied by the output voltage.

#### Constant Current Control

Cycle by Cycle current sense is adopted in BP3211, the CS pin is connected to the current sense comparator, and the voltage on CS pin is compared with the internal 400mV reference voltage. The MOSFET will be switched off when the voltage on CS pin reaches the threshold.

The peak inductor current is given by:

$$I_{PK} = \frac{400}{R_{CS}} \text{ (mA)}$$

Where,  $R_{CS}$  is the current sense resistor value.

The CS comparator includes a 350ns leading edge blanking time.

The VLN pin detects the TRIAC dimmer conducting angle to adjust the LED driver output current. The application circuit of the VLN pin is shown in Figure 4. When the VLN pin voltage is higher than 3V, the threshold for peak current limit  $V_{CS\_TH}$  decreases linearly as shown in Figure 5. When the VLN pin is not used, it can be grounded or floated.

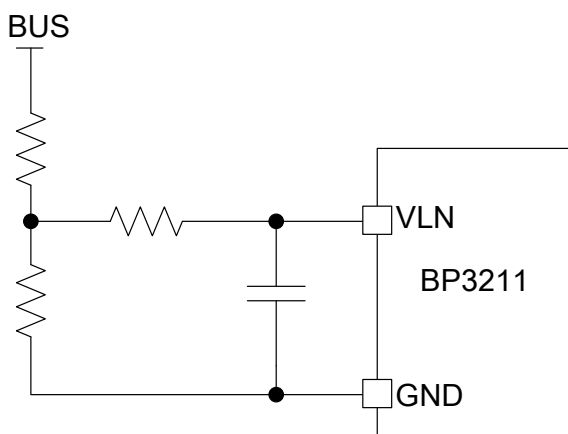


Figure 4. VLN pin application circuit

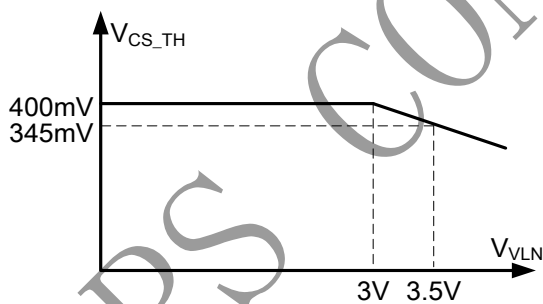


Figure 5. Relationship of VLN voltage and  $V_{CS\_TH}$

### Inductor Selection

The BP3211 works under inductor current critical conduction mode. When the power MOFET is switched on, the current in the inductor rises up from zero, the on time of the MOSFET can be calculated by the equation:

$$t_{on} = \frac{L \times I_{PK}}{V_{IN} - V_{LED}}$$

Where,

L is the inductance value.

$V_{IN}$  is the DC bus voltage after the rectifier bridge.

$V_{LED}$  is the voltage on the LED.

The maximum on time of the MOSFET is set to 10us internally.

After the power MOSFET is switched off, the current in the inductor decreases. When the inductor current reaches zero, the power MOSFET is turned on again by IC internal logic. The off time of the MOSFET is given by:

$$t_{off} = \frac{L \times I_{PK}}{V_{LED}}$$

The inductance can be calculated by the equation:

$$L = \frac{V_{LED} \times (V_{IN} - V_{LED})}{f \times I_{PK} \times V_{IN}}$$

Where, f is the maximum system switching frequency, which is proportional to the input voltage. So the minimum switching frequency is set at lowest input voltage, and the maximum switching frequency is set at highest input voltage.

### Over Voltage Protection

The FB pin is used to detection the output voltage for over voltage protection (OVP). The FB pin threshold is 1V.

The resistor divider of the FB pin can be set as:

$$\frac{R_{FBL}}{R_{FBL} + R_{FBH}} = \frac{1}{V_{OVP}}$$

Where,

$R_{FBL}$  is the lower resistor of the resistor divider

$R_{FBH}$  is the higher resistor of the resistor divider

$V_{OVP}$  is the over voltage protection set value.



For maximizing the system efficiency, the lower resistor is recommended to be around 5K $\Omega$ .

### Protection Function

The BP3211 offers rich protection functions to improve the system reliability, including LED open/short protection, CS resistor short protection, V<sub>CC</sub> under voltage protection, thermal regulation.

When the LED is open circuit, the system will trigger the over voltage protection and stop switching.

When the LED short circuit is detected, the system works at low frequency (4kHz), and the CS pin turn off threshold is reduced to 200mV. So the system power consumption is very low. At some catastrophic fault condition, such as CS resistor shorted or inductor saturated, the internal fast fault detection circuit will be triggered, the system stops switching immediately.

After the system enters into fault condition, the V<sub>CC</sub> voltage will decrease until it reaches the UVLO threshold, then the system will re-start again. If the fault condition is removed, the system will recover to normal operation.

### Thermal Regulation

The BP3211 integrates thermal regulation function. When the system is over temperature, the output current is gradually reduced; the output power and thermal dissipation are also reduced. The system temperature is regulated and the system reliability is improved. The thermal regulation temperature is set to 150°C internally.

### PCB Layout

The following rules should be followed in BP3211

PCB layout:

Bypass Capacitor

The bypass capacitor on V<sub>CC</sub> pin should be as close as possible to the V<sub>CC</sub> Pin and GND pin.

FB Pin

The feedback resistor divider should be as close as possible to the FB pin, and the trace must keep away from dynamic node of the inductor and Drain pin trace, otherwise the FB pin OVP function might have risk to be mis-triggered by the system noise.

V<sub>LN</sub> Pin

The V<sub>LN</sub> pin resistor divider and capacitor should be as close as possible to the V<sub>LN</sub> pin, and the V<sub>LN</sub> node should be away from the high voltage switching nodes.

Ground Path

The power ground path for current sense resistor should be short and wide, and it should be as close as possible to the IC GND pin. The IC signal ground for FB resistors should be connected to the IC GND pin with short traces and should be away from the power ground path.

The Area of Power Loop

The area of main current loop should be as small as possible to reduce EMI radiation, such as the power MOSFET, the output diode and the bus capacitor loop.

DRAIN Pin

To increase the copper area of DRAIN pin for better thermal dissipation. However, too large copper area may compromise the EMI performance.

**Physical Dimensions**
