BP2333

Non-isolated Buck APFC LED Driver

Description

The BP2333 is a high precision non-isolated buck driver with active PFC, specially designed for universal input offline constant current LED lighting. The driver with on-chip PFC circuit achieves high power factor and low THD. Operating in critical conduction mode, the power MOSFET switching loss is reduced and the inductor is fully utilized.

The BP2333 integrates a 500V power MOSFET. With few external components, the LED output current can be precisely controlled.

The BP2333 utilizes patented floating ground structure. The inductor current is sensed during the whole switching cycle. So it achieves high precision output current control, and excellent line regulation and load regulation.

The BP2333 utilizes patented start up technology with HV JFET. So it achieves fast start up, reduce count of external components, and realize smaller form factor.

The BP2333 offers rich protection functions to improve the system reliability, including LED open circuit protection, LED short circuit protection, VCC under voltage protection, CS resistor open circuit protection and cycle by cycle current limit. All the protection functions are auto-recovery. The system reliability is further improved by the thermal regulation function. The output current is reduced when the driver is over temperature.

Features

- Fast start up and power supply with HV JFET
- Integrated with 500V Power MOSFET
- Active PFC for High Power Factor and Low THD
- System Efficiency up to 95%
- ±3% LED Output Current Accuracy
- Excellent Line and Load Regulation
- Critical Conduction Mode Operation
- Ultra Low (300uA) Operating Current
- LED Short/Open Protection
- Current Sensing Resistor Open Protection
- Cycle by Cycle Current Limit
- VCC Under Voltage Protection
- Auto Fault Recovery
- Thermal Regulation Function

Applications

- LED retrofit lamps, Bulb, Spot Light, GU10/E27
- LED PAR30, PAR38 Lamp
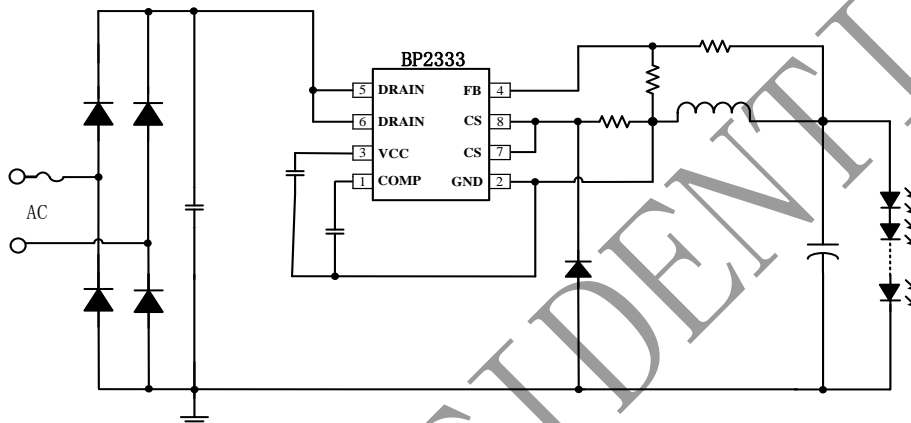- LED tube, LED String
- Other LED Lighting

Typical Application

Figure 1. Typical application circuit for BP2333

Ordering Information

Part Number	Package	Operating Temperature	Package Method	Marking
BP2333	SOP-8	-40 ℃ to 105 ℃	Tape 4,000 pcs/Reel	BP2333 XXXXXY WWXYY

Pin Configuration and Marking Information

COMP

GND

VCC

FB

BP2333

WWXXYY

XXXXXY

CS

CS

DRAIN

DRAIN

XXXXXY: Lot Code
W: Sign
X: Year
YY: Week
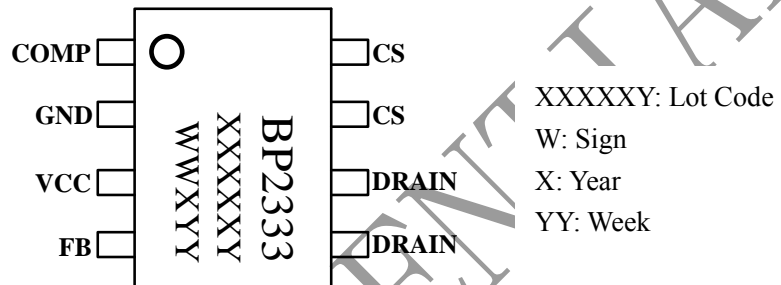
Figure 2. Pin configuration

Pin Definition

Pin No.	Name	Description
1	COMP	Loop Compensation Node. This pin connects a capacitor to GND for stabilization of the control loop, achieving accurate LED current, high Power Factor and low THD.
2	GND	Ground.
3	VCC	Power Supply Pin. Connect a bypass capacitor from this pin to GND.
4	FB	Feedback Voltage detection Pin. This pin detects the inductor demagnetization signal and the output voltage.
5,6	DRAIN	Internal HV Power MOSFET Drain.
7,8	CS	Current Sense Pin. Connect a resistor to GND to sense the inductor current.

Absolute Maximum Ratings (note1)

Symbol	Parameters	Range	Units
V_{DS}	Internal HV MOSFET Drain to Source voltage	-0.3~500	V
I_{CC_MAX}	VCC pin maximum sink current	20	mA
COMP	Compensation pin voltage	-0.3~6	V
FB	Feedback Voltage detection Pin	-0.3~6	V
CS	Current sense pin	-0.3~6	V
P_{DMAX}	Power dissipation (note2)	0.45	W
θ_{JA}	Thermal resistance (Junction to Ambient)	145	℃/W
T_J	Operating junction temperature	-40 to 150	℃
T_{STG}	Storage temperature range	-55 to 150	℃
	ESD (note3)	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}, θ_{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 1.5kΩ resistor

Recommended Operation Conditions

Symbol	Parameter		Range	Unit
I_{LED} 1	Output LED current @ Vout=72V	Input voltage 90Vac	〈 120	mA
		Input voltage 176Vac	〈 150	mA
I_{LED} 2	Output LED current @ Vout=36V	Input voltage 90Vac	〈 190	mA
		Input voltage 176Vac	〈 220	mA

Electrical Characteristics (Notes 4, 5) (Unless otherwise specified, V_{CC}=9V and T_A=25 ℃)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage Section						
V_{CC_ON}	V_{CC} Turn On Threshold	V_{CC} Rising		9.9		V
V_{CC_UVLO}	V_{CC} Turn Off Threshold	V_{CC} Falling		7.4		V
V_{CC_HIGH}	VCC Charge Limit	V_{CC} Rising		9.9		V
$V_{CC\_HIGH\_HYS}$	VCC Hysteresis Window	V_{CC} Falling		1		V
V_{CC_CLAMP}	V_{CC} Clamp Voltage			12		V
I_{CC_UVLO}	V_{CC} Startup Current	V_{CC} Rising, V_{CC}= V_{CC_ON} - 1V		40	80	uA
I_{CC}	V_{CC} Operating Current	F_{OP}=7kHz,		300	500	uA
Feedback Section						
V_{FB_FALL}	FB Falling Edge Threshold Voltage	FB Falling		0.2		V
V_{FB_HYS}	FB Hysteresis Voltage	FB Rising		0.15		V
V_{FB_OVP}	FB Over Voltage Protection Threshold			1.6		V
T_{ON_MAX}	Maximum On Time			35		us
T_{OFF_MIN}	Minimum Off Time			2.5		us
T_{OFF_MAX}	Maximum Off Time			150		us
Current Sense Section						
V_{CS_LIMIT}	CS Peak Voltage Limitation			1.5		V
T_{LEB_CS}	Leading Edge Blanking Time for Current Sense			300		ns
T_{DELAY}	Switch off Delay Time			200		ns
Compensation Section						
V_{REF}	Internal Reference Voltage		0.194	0.200	0.206	V
V_{COMP_LO}	COMP Low Clamp Voltage			1.5		V

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{COMP}	COMP Linear Operating Voltage Range		1.5		4.0	V
V_{COMP_HI}	COMP High Clamp Voltage			4.0		V
Power MOSFET						
R_{DS_ON}	Static Drain-source On-resistance	V_{GS}=10V/I_{DS}=0.5A		8		Ω
B_{VDSS}	Drain-Source Breakdown Voltage	V_{GS}=0V/I_{DS}=250uA	500			V
I_{DSS}	Power MOSFET Drain Leakage Current	V_{GS}=0V/V_{DS}=500V			1	uA
HV JFET						
I_{JFET}	JFET current	Drain of JFET to GND 40v		9		mA
B_{VDSS}	JFET Drain to Source		500			V
I_{DSS}	JFET shut down Leakage Current			45		uA
Thermal Regulation Section						
T_{REG}	Thermal Regulation Temperature			140		℃

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

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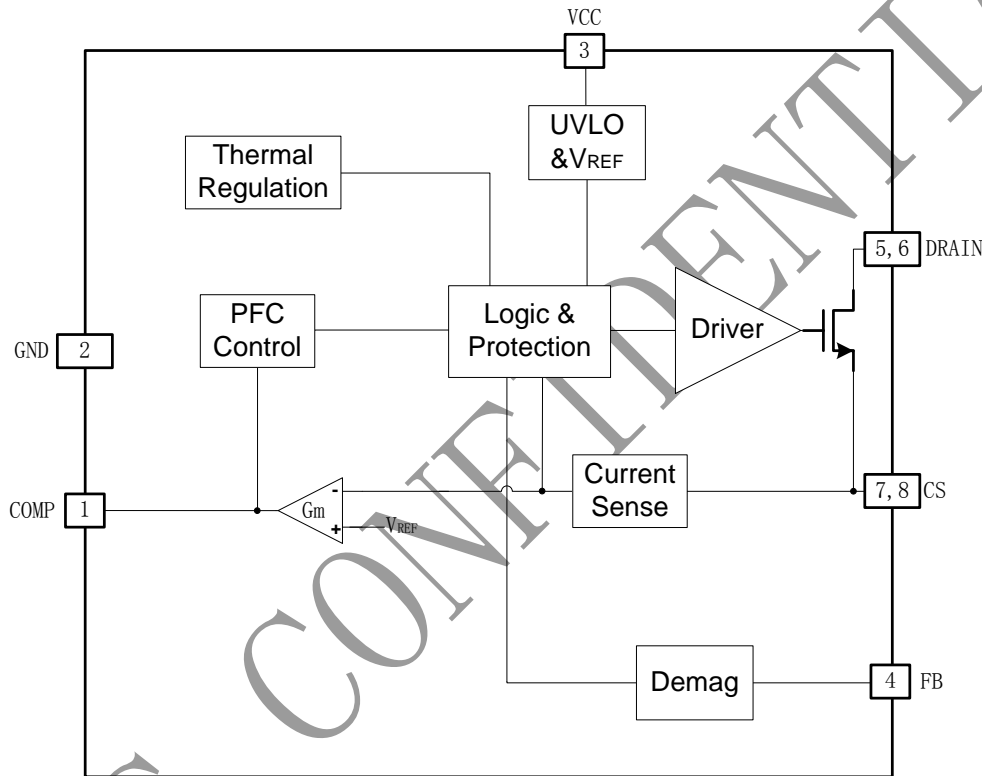
Internal Block Diagram

Figure 3. BP2333 Internal Block Diagram

Application Information

The BP2333 integrating a 500V power MOSFET, is a high precision non-isolated buck APFC LED driver, specially designed for universal mains with constant current control. The driver with on-chip PFC circuit achieves high power factor, low THD and high efficiency.

1 Start Up

After system powered on, the capacitor on VCC pin is charged up by the startup resistor. When the VCC pin voltage reaches the turn on threshold, the internal circuits start working. The COMP pin voltage is pulled up to 1.5V quickly, then the system starts switching from 10kHz frequency at the beginning, the COMP voltage rises up gradually, and the inductor peak current also rises up. The LED current hence achieves a soft start without overshoot. After the output voltage is built up, the VCC power is supplied

by the output voltage through a diode.

2 Constant Current Control

The BP2333 utilizes patent pending floating ground structure. The inductor current is sensed during the whole switching cycle, thus it achieves high precision output current control and also excellent line and load regulation.

The LED current can be calculated by the equation:

$$I_{OUT} \approx \frac{V_{REF}}{Rcs}$$

Where,

V_{REF}: Internal reference voltage

Rcs: Value of the current sensing resistor

3 Feedback Network

The BP2333 senses the zero current crossing information through the feedback network, the FB falling threshold voltage is set to 0.2V with 0.15V hysteresis. The FB pin is multiple used to detect output voltage, the OVP threshold voltage is 1.6V. The ratio of FB upper resistor to lower resistor can be set as:

$$\frac{R_{FBL}}{R_{FBL} + R_{FBH}} = \frac{1.6V}{V_{OVP}}$$

Where,

R_{FBL}: The lower resistor of the feedback network
R_{FBH}: The upper resistor of the feedback network
V_{OVP}: Output over voltage setting point

4 Thermal Regulation

The BP2333 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 typical thermal regulation temperature is set to 140 ℃ internally.

5 Protection Functions

To improve the system reliability, BP2333 offers protection functions:

When the LED is open circuit, the output voltage will gradually rise up. The output voltage is sensed by the FB pin when power MOSFET is turned off. When FB voltage reaches the OVP threshold, it will trigger fault logic and the system stops switching.

When the LED is shorted circuit, the switching frequency will work under 7 kHz. Meanwhile, the output voltage is low and the VCC pin cannot be charged up by the output voltage, so the VCC pin voltage will gradually decrease and finally reaches the UVLO threshold.

After the system enters into fault condition, the VCC voltage will decrease until it reaches UVLO threshold. Then the system will re-start again. If the fault condition is removed, the system will resume normal operation.

When the output is short circuit or the inductor is saturated, the CS peak voltage will be relatively high. When CS voltage reaches the internal limitation (1.5V), the power MOSFET will be turned off instantaneously. This cycle by cycle current limitation can help protecting the power MOSFET, the inductor and the output diode.

6 PCB Layouts

The following guidelines should be followed in BP2333 PCB layout:

Bypass Capacitor

Put the bypass capacitor close to VCC pin, and loop compensation capacitor to COMP pin.

Ground Path

Keep a short and wide ground path for current sense resistor. The IC signal ground for COMP and FB components should be connected to the IC GND.

The Area of Power Loop

The area of main current loop should be as small as possible to reduce EMI radiation.
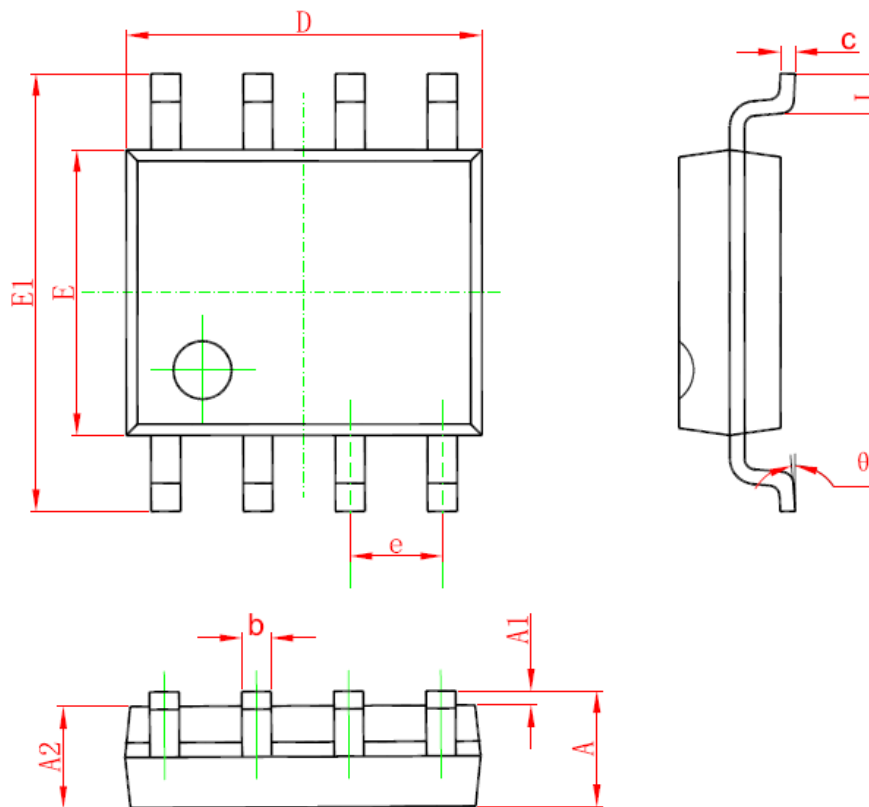
FB Pin

Put the divider resistor close to the FB pin as possible, and keep the trace away to the switching node.

DRAIN Pin

To increase the copper area of DRAIN pin for better thermal dissipation.

Physical Dimensions

SOP8 PACKAGE OUTLINE DIMENSIONS

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°