



BP2808

85~265Vac Input LED Constant Current Driver

General Description

The BP2808 is a current mode control LED driver IC. The BP2808 can support DC voltage which ranges from 12V to 600V, with duty cycle up to 100%. The BP2808 can be used in non-isolation LEDs driving system and can support AC supply voltage from 85V to 265V. The BP2808 uses patented technique for source driver and constant current compensation, so LEDs current has $\pm 3\%$ accuracy with AC supply voltage variation from 85V to 265V. What's more, the patented technique for the driving scheme ensures 90% higher efficiency in the application of 18W LEDs lighting with AC voltage range from 85V to 265V. In AC voltage range from 85V to 265V, the BP2808 can drive 3W-36W LEDs array which is widely used in E14/E27/PAR30/PAR38/GU10 lighting and tube LEDs lighting.

The BP2808 has multiple LED protections, including LED open-circuit protection, LED short-circuit protection and thermal shutdown protection. If system has a failure, the BP2808 will operate in protection mode until system recovers.

The BP2808 is available in SOP8 packages.

Application

- ◆ LED Tube lighting
- ◆ E14/PAR30/PAR38/GU10/E27 LED spotlight
- ◆ LED Street lighting
- ◆ LED Signal lighting
- ◆ LED down-light

Features

- ◆ Source driver structure
- ◆ Constant current compensation
- ◆ System DC supply voltage: 12V to 600V.
System AC supply voltage: 85V to 265V.
- ◆ Duty Cycle up to 100%.
- ◆ Typical $\pm 5\%$ output current accuracy.
- ◆ Up to 95% system efficiency.
- ◆ LED open-circuit protection; LED short-circuit protection.
- ◆ Internal thermal shutdown protection.
- ◆ Single DIM pin for dynamic temperature compensation and brightness control using DC voltage or PWM signal

Typical Application

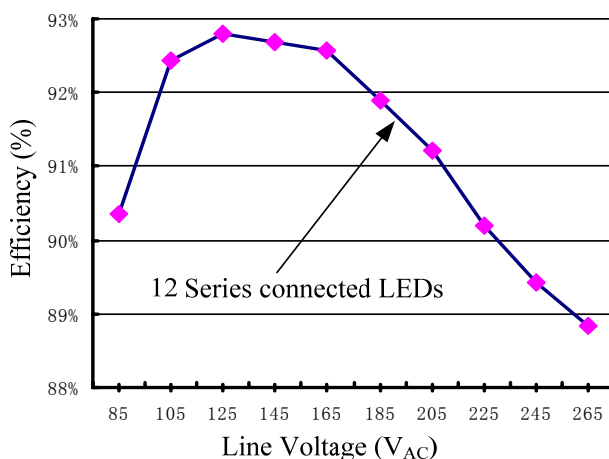


Figure 1 Efficiency vs. Line Voltage

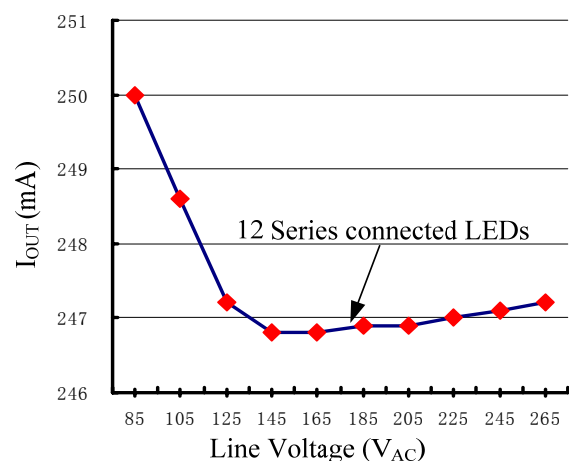


Figure 2 Output Current vs. Line Voltage



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Typical Application Circuit

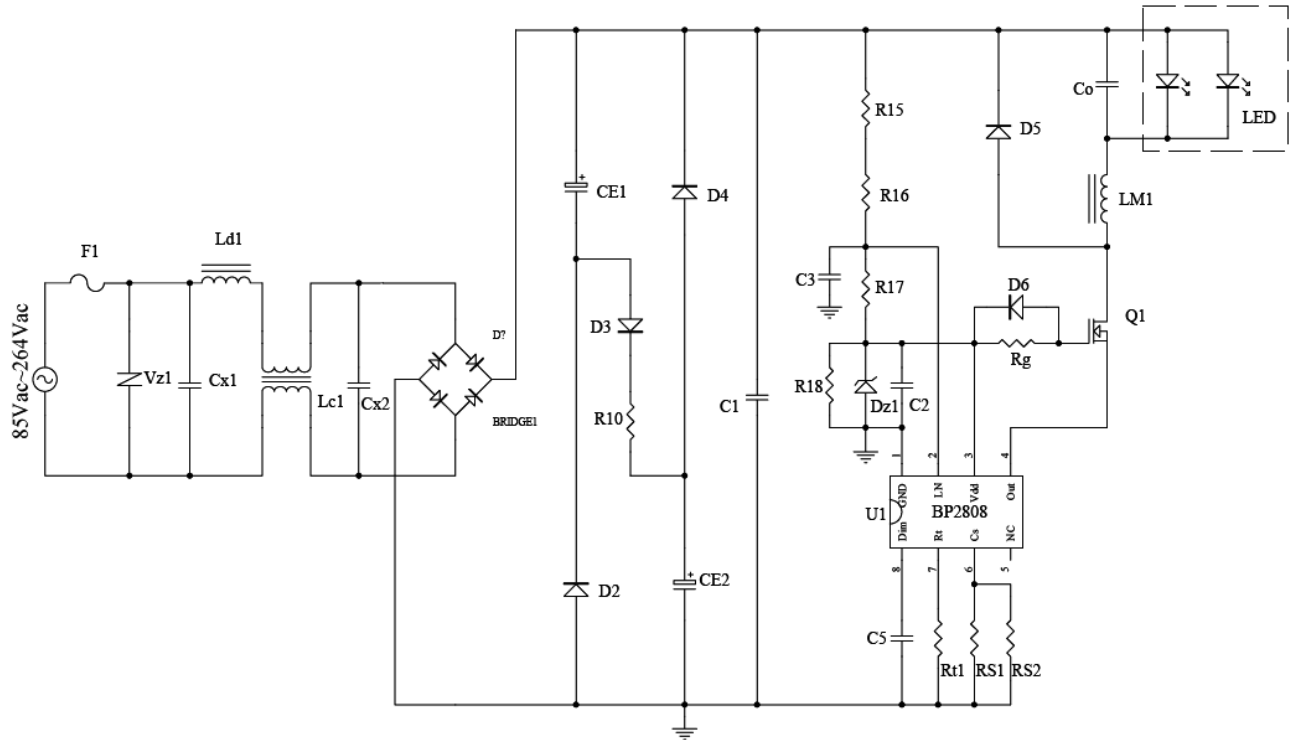


Figure 3 Typical Application Circuit for AC supply

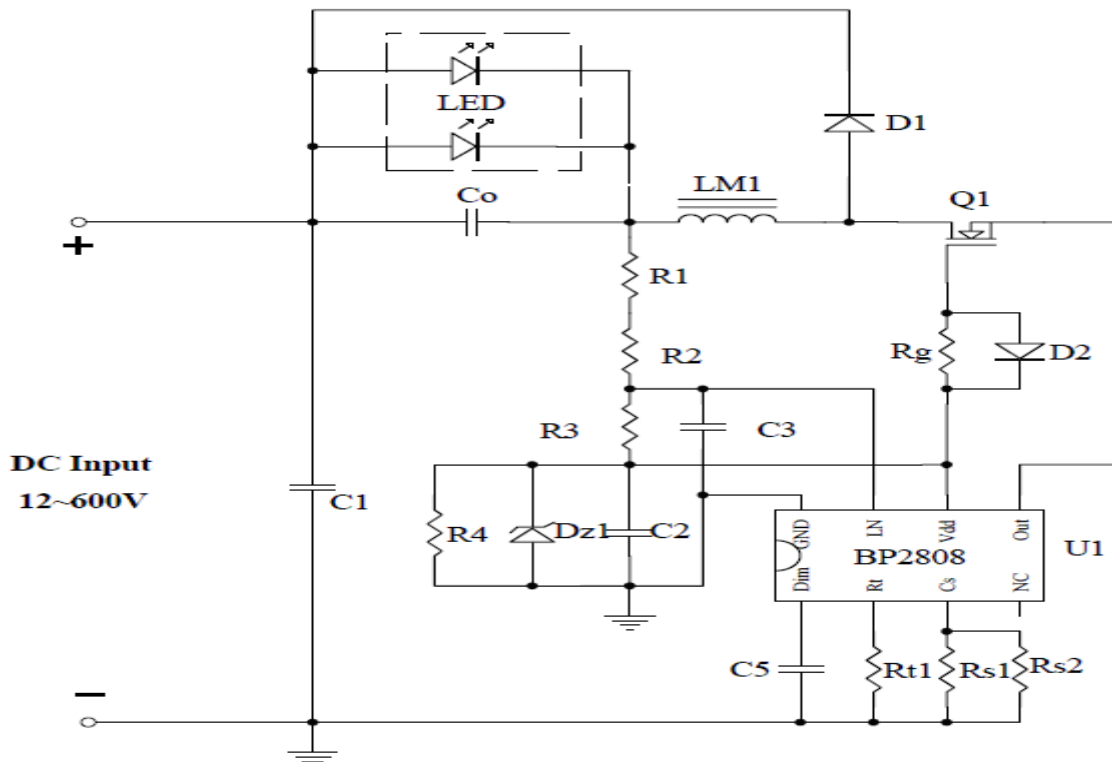


Figure 4 Typical Application Circuit for DC Supply

Pin ASSIGNMENT

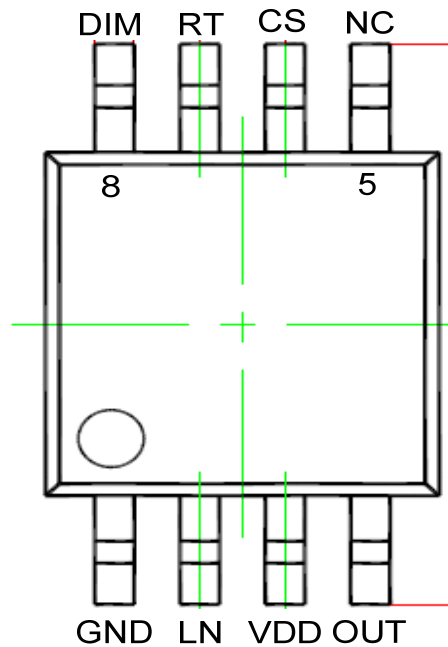


Figure 5 Pin Assignment

Pin Description

PIN No.	PIN NAMES	DESCRIPTION
1	GND	Signal and power ground. Connect directly to ground plane.
2	LN	Line voltage compensation of the peak threshold. Sensing the voltage between LN and VDD.
3	VDD	Input Supply Pin. Must be locally bypassed.
4	OUT	Drain of internal power switch, source of external power switch.
5	NC	No connection
6	CS	Current sense input, sampling resistor connected between CS and GND
7	RT	Fixed turn off time setting
8	DIM	Enable switch, analog and PWM dimming input.

ORDERING INFORMATION

ORDERING PART	PACKAGE	TEMPERATURE RANGE	TRANSPORT MEDIA	MARKING
BP2808ESO8	SOP8	-40 °C to 85 °C	Tape and Reel	BP2808



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ABSOLUTE MAXIMUM RATINGS (Note 1)

SYMBOL	ITEMS	VALUE	UNIT
V _{DD}	Supply Voltage	-0.3~18	V
LN	Line voltage compensation	-0.3~18	V
OUT	Drain of internal power switch.	-0.3~20	V
CS	Pin of current sense	-0.3~6	V
DIM	Enable switch, analog and PWM dimming input.	-0.3~6	V
RT	Fixed turn off time setting	-0.3~6	V
I _{OUT}	Output current of power switch	0.8	A
P _{DMAX}	Power Dissipation (Note 2)	0.5	W
P _{TR}	Thermal Resistance SOP8 (θ_{JA})	150	°C /W
T _J	Operation Junction Temperature Range	-40 to 150	°C
T _{STG}	Storage Temperature	-55 to 150	°C
	ESD Susceptibility (Note 3)	3	kV

Note 1: Absolute Maximum Ratings indicate that operating beyond these ratings may damage the device. **Recommended Operating Range indicates** that the device is functional in that range, 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 decreasing with elevating 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 lower number given in Absolute Maximum Ratings.

Note 3: Human body model, 100pF capacitor discharged through a 1.5k Ω resistor.

RECOMMENDED OPERATING RANGE

SYMBOL	ITEMS	VALUE	UNIT
V _{DD}	V _{DD} Supply Voltage	0 ~ 16	V
T _{OPT}	Operating Temperature	-40 to +85	°C



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ELECTRICAL CHARACTERISTICS (Note 4, 5)

(The following specifications apply for $V_{IN}=12V$, $T_A=25^\circ C$, unless specified otherwise.)

SYMBOL	ITEMS	CONDITIONS	Min.	Typ.	Max.	UNIT
V_{DD}	Input Voltage		11		16	V
V_{UVLO}	Under voltage lock out	V_{DD} rising		8.5	10	V
I_{ST}	Start up current	$V_{DD}=8V$ before startup		30	100	μA
$V_{UVLO, HYS}$	UVLO hysteresis			2.5		V
Current Sense						
V_{CS-TH}	Current sense threshold voltage	$\Delta V_{LN} = 0$	240	250	260	mV
T_{LEB}	Current sense blank interval	$V_{CS}=V_{CS-TH}+50mV$		500		ns
T_{DELAY}	Delay to output	$V_{CS}=V_{CS-TH}+50mV$		650		ns
$\Delta V_{CS-TH} @ \Delta V_{LN}$	$\Delta V_{LN} = V_{LN} - V_{DD}$	$\Delta V_{LN} = 1V$		-30		mV
Fixed Toff control						
T_{OFF}	Fixed turn off interval	$R_T=270K$	9.7	10.8	12	μs
V_{RT}	RT voltage		1.1	1.25	1.4	V
Operating Current						
I_{OFF}	Quiescent supply current with output off	$V_{DIM}<0.4V$		90		μA
I_{OP}	Operating supply current	$f_{OP}=50kHz$		200		μA
DIM Input						
V_{DIM}	Internal supply voltage	DIM floating		5		V
V_{DIM_H}	DIM input voltage High		2.5			V
V_{DIM_L}	DIM input voltage Low				0.3	V
V_{DIM_DC}	DC brightness control		0.5		2.5	V
R_{DIM}	DIM pull up resistor to Internal supply voltage			100		k Ω
I_{DIM_L}	DIM input leakage low	$V_{DIM} = 0$		50		μA
Output Switch						
R_{SW}	SW On Resistance	$V_{DD} = 12V$		0.8		Ω
I_{SWmean}	Continuous SW Current				700	mA
I_{LEAK}	SW Leakage Current			0.5	5	μA
Thermal Shutdown						
T_{SD}	Thermal Shutdown Threshold			150		$^\circ C$



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T _{SD-hys}	Thermal Shutdown hysteresis		20	°C
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Note 4: Typical parameters are measured at 25°C and represent the parametric norm.

Note 5: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

Application Information

The BP2808 is a special constant current LEDs driver. BP2808 operates in continuous conduction mode step-down converter system. By controlling LEDs peak current and ripple current, BP2808 can regulate LEDs mean current. Using a few external components, BP2808 provides a solution to constant current control, with DC voltage dimming and PWM signal dimming.

The resistor connected to RT programs MOSFET turn off time. At the beginning of each cycle, MOSFET is turned on until the inductor current ramps up to its peak value $I_P = V_{REF} / R_{CS} (mA)$. Once the MOSFET is turned off, its off time is set by $T_{off} = 4 \times 10^{-5} \times R_T (us)$. When the off time is complete, MOSFET is turned on again and repeats this operation. The off time control the ripple current

$I_R = \frac{10^3 \times T_{OFF} \times V_{LED}}{L} (mA)$ and LED mean current $I_{LED} = I_P - \frac{1}{2} \times I_R (mA)$. In the case of fixed

quantity LEDs system, voltage of each LED is relatively stable. So LEDs output current is constant, when inductor value is settled. It is remarkable that, theoretically, LEDs current is independent on the line voltage (Vbulk). However, practically, because of system delay, the peak current will follow with the increasing input line voltage. The BP2808 uses a patented technique to compensate the peak current variation. The pin 'LN' is used to detect input line voltage and compensate output current. For example, if the potential difference of LN and VDD is 1V, the CS threshold will decrease 30mV. In this way, system can provide constant current in a wider voltage range. Moreover, the LN pin can compensate the output voltage variation, as well. For more information, please refer to AN-211.

To achieve high system efficiency, BP2808 utilizes special technique to drive power MOSFET by source driver scheme. In this way, the chip operating current is extremely low. On the same time, system efficiency is greatly enlarged by using power MOSFET's dissipation to supply chip through the feeding diode.

The DIM pin of BP2808 can be used as enable switch, DC voltage dimming and PWM dimming input. DIM pin of BP2808 can use DC voltage dimming to compensate system temperature dynamically, as well.

BP2808 has the feature of thermal shutdown, output LEDs short-circuit protection and open-circuit protection. This device is suitable for high efficient LEDs tube lighting and spotlight.

Typical Application Circuit:

Following is the BP2808 application circuit diagram as an 18W (24 series LEDs with 12 parallel connections) LEDs driver, which is designed for application in China.

- ◆ Schematic

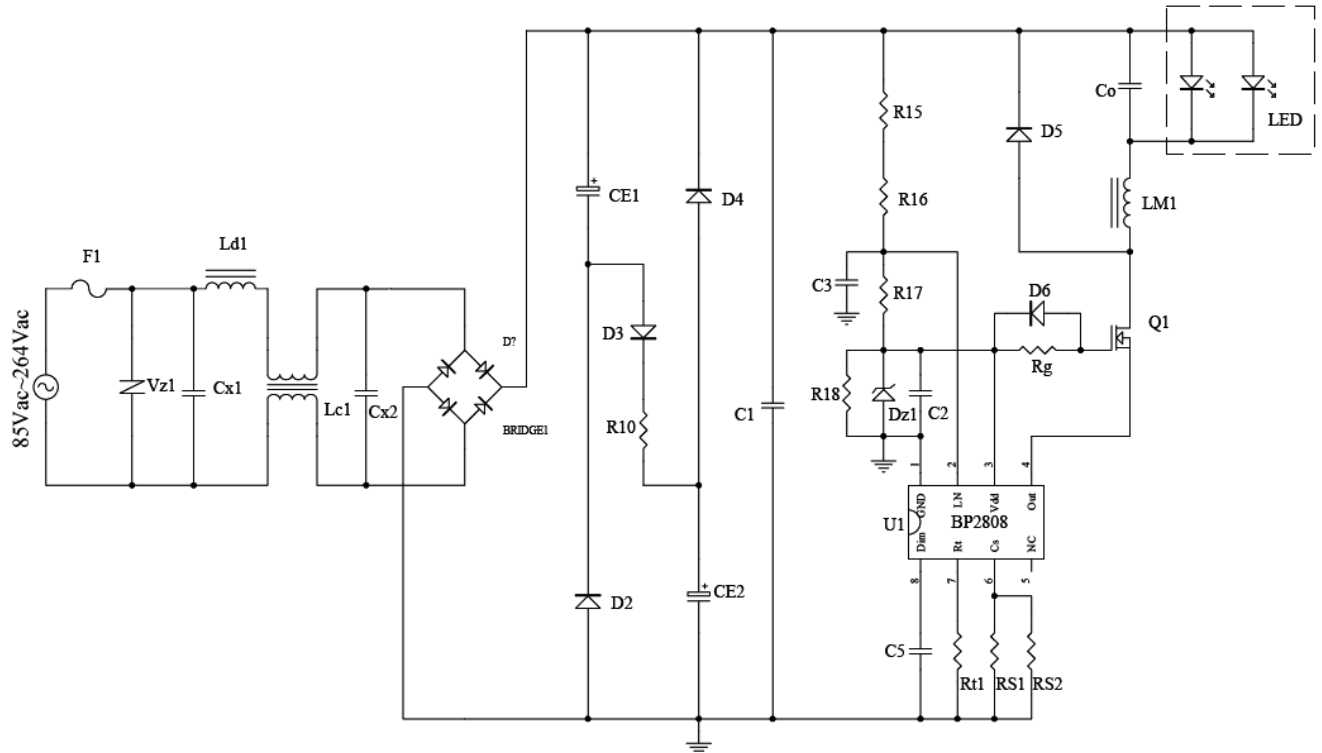


Figure 6 Schematic

- ◆ Power SPEC.

Input Voltage Range:	$V_{in}=176V-265V$
Input Frequency:	$F_{in}=50Hz$
LED Voltage:	$V_{led}=3.2V$
LED Current:	$I_{led}=20mA$
System Efficiency:	$\eta=90\%$
Power Factor:	$PF=0.9$
IL Ripple Factor:	$\Delta I_L=65\%$

- ◆ Parameters Calculation:

Output Voltage:	$V_{out}=24s*3.2V=76.8V$
Output Current:	$I_{out}=12p*20mA=240mA$
Output Power:	$P_{out}=76.8*240=18.4W$
Inductor Peak Current:	$I_{Lpk}=240+(240*65\%)=396mA$
Inductor Ripple Current:	$I_{Lrp}=2*(396-240)=312mA$
Turn Off Time:	$T_{off}=10.8\mu S$



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◆ Key Components Parameter Design:

1、 Fuse (F1)

- a) Depending on application region, the fuse must meet corresponding certification. Such as:
 America Region: UL(USA), CSA(CA);
 Euro Region: CE(EU), VDE (DE), SEMKO (SE) ,IMQ (ITA);
 China Mainland: CCC;
 Japan: PSE
- b) Rating Current:

$$I_R = \frac{2 \times P_{O_MAX}}{V_{IN_MIN} \times PF \times \eta_{MIN}}$$

$$=[20/(176*0.85*90%)]*2=297mA$$

In practical, the current of fuse must be larger than 297mA.

- c) I^2*t : Calculate or measure the surge current. Calculate the value of I^2*t based on the current waveform. Based on the rating current and I^2*t to select the suitable product model from producer's catalogue.
- d) For example: slow off, VDE 500mA 5.5mm*15mm

2、 Bulk Capacitors (CE1,CE2)

a) Capacitor Capacity

To improve system power factor (PF), Valley-Fill circuit is used, series scheme for charge and parallel scheme for discharge. In design, V_{bulk} must be guaranteed to be higher than V_{out} all the time, normally 25% margin. The value of CE can be get as following:

$$CE = \frac{I_O \times D_{MAX}}{\eta_{MIN} \times 6 \times f_{IN_MIN} \times (0.707 \times V_{IN_MIN} - 1.25 \times V_{O_MAX})}$$

$$=38.9\mu F$$

V_{O_MAX} is $24 \times 3.6 = 86.4V_{dc}$, $D_{MAX} = 0.8$, V_{IN_MIN} is 176Vac, $\eta_{MIN} = 90\%$, $f_{IN_MIN} = 50Hz$

b) Capacitor Breakdown Voltage

Because of Valley-Fill circuit is series scheme for charge, the highest voltage across capacitor is

$$V_{CE1/2} = \frac{\sqrt{2}}{2} \times V_{IN_MAX}$$

$$=0.5*1.414*265=187V$$

So 250V breakdown voltage is enough, in this example.

- c) Because of using parallel scheme for discharge, CE1/CE2 use 22uF/250V 105°C electrolytic capacitor.



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3、 Main Inductor (LM1)

a) Inductance

$$L_B = \frac{V_{Out}}{ILrp} \times T_{off}$$
$$= 76.8 \times 10.8 / 0.32 = 2.6 \text{mH}$$

b) Coil Diameter

$$D = 1.13 \times \sqrt{I_{out}/J} \quad J: \text{current density, used as } 6$$
$$= 1.13 \times \sqrt{0.24/6} = 0.226 \text{mm}$$

used as: 0.23mm

c) Magnetic Core

I-Core inductor is widely used for its low cost, but attention must be paid to use this kind of inductor:

- Nickel-zinc I-Core-inductor. There are too many categories of nickel-zinc inductor. Their initial magnetic permeability are about tens to thousands Gauss. So it's difficult to guarantee inductor performance without careful product test. To use such kind of inductor, the inductor magnetic core and inductor product model must be matched.
- Mn-Zn I-Core inductor. The initial magnetic permeability variation of Mn-Zn inductor is less. However, as this kind of inductor has no insulation, the magnetic core must be covered by a layer of insulation and be fixed with an insulation base, before using.
- Magnetic path. As the magnetic path of I-Core inductor is open loop, it is important to reduce its interference, especially to be utilized with metal light tube. So EE type or loop type Mn-Zn inductor is recommended for main inductor LB.

EE-13 inductor is used in this example. Its Bm value is 2445Gs, with 0.23mm 245 Ts.

4、 MOSFET (Q1)

a) Breakdown Voltage

Breakdown voltage must larger than the peak value of maximum input voltage.

$$V_{DS} = \sqrt{2} \times V_{IN_MAX}$$
$$= 1.414 \times 265 = 374.71 \text{V}$$

b) Current

The RMS value of MOSFET current is:

$$I_{S_RMS} = 2 \times \frac{P_{O_MAX}}{V_{O_MIN} \times \eta_{MIN}}$$
$$= 2 \times 20.7 / (0.9 \times 70) = 0.64 \text{A}$$

If margin is 25%

$$I_{mos} = 0.64 \times 1.25 = 0.8 \text{A}$$

- #### c) To enlarge system efficiency, MOSFET with higher current (lower Rdson) is recommended.
- #### d) STD2HMK60Z-1(Package: IPAK) is used in this example.



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5、 Diode (D5)

a) Breakdown Voltage

Breakdown voltage must higher than the peak value of maximum input voltage.

$$V_{DS} = \sqrt{2} \times V_{IN_MAX}$$
$$= 1.414 \times 265 = 374.71V$$

b) Current

The RMS value of Diode current is:

$$I_{D_RMS} = 2 \times \frac{P_{O_MAX}}{V_{O_MIN} \times \eta_{MIN}}$$
$$= 2 \times 20.7 / (70 \times 0.9) = 640mA$$

If margin is 25%

$$I_{db} = 0.64 \times 1.25 = 0.8A$$

c) As diode operates in high frequency, super fast recovery diode is recommended.

d) MUR160 (Package: DO-15) is used in this example.

6、 Current Sense Resistor (RS1, RS2)

a) Resistor Value

$$R_{CS} = \frac{V_{REF}}{I_{L_PK}}$$
$$= 250 / 396 = 0.63\Omega$$

b) Rating Power

$$P_{Rcs} = 0.25^2 / 0.63 = 0.099W$$

c) SMD_0805_1.25Ω±1% with two parallel connections is used in this example.

7、 Toff time set resistor (Rt1)

$$R_{t1} = T_{off} / (4 \times 10^{-5}) = 270K$$

SMD_0805_270K±1% is used in this example.

8、 Start-up and compensation resistor (R15,R16,R17)

a) Start-up resistor (Rst1,Rst2)

$$R_{ST} + R_{LN} = \frac{V_{IN_MIN}}{I_{ST_MAX}}$$
$$= 176 / 100\mu A = 1760K$$

In this example R15, R16 are both of 510K.

b) Compensation resistor (RLN)

The internal compensation resistor is about $k \approx 0.1\%$, in this example.

$$R_{LN} = k \times R_{ST}$$
$$= 1020 \times 0.1\% = 1.02k\Omega$$

In this example R17 is 1.0K



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9、 DIM pin

DIM pin can be used as DC voltage and PWM dimming input. Float this pin, if it is not used.

As for analog dimming, only a 150K potentiometer can achieve 0% to 100% dimming range. As for PWM dimming, the recommended frequency is 270Hz.



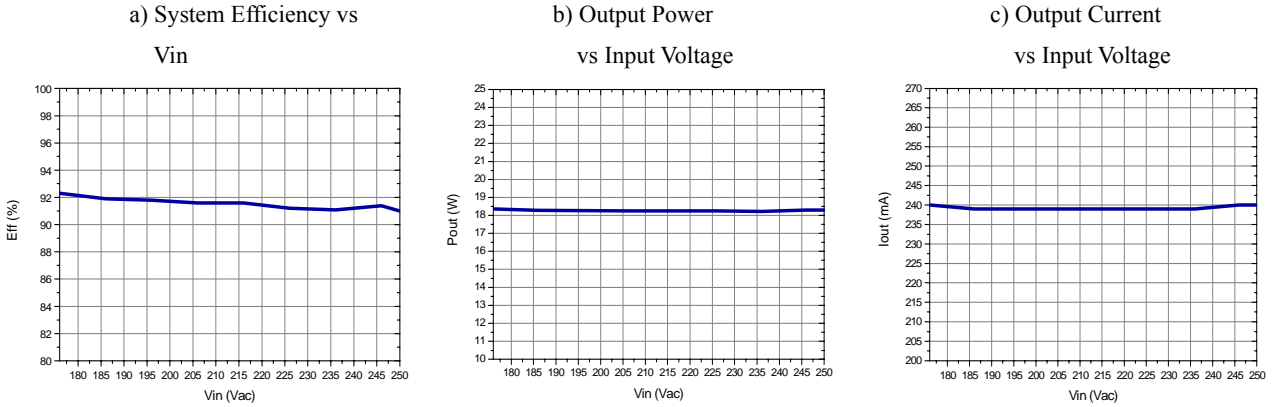
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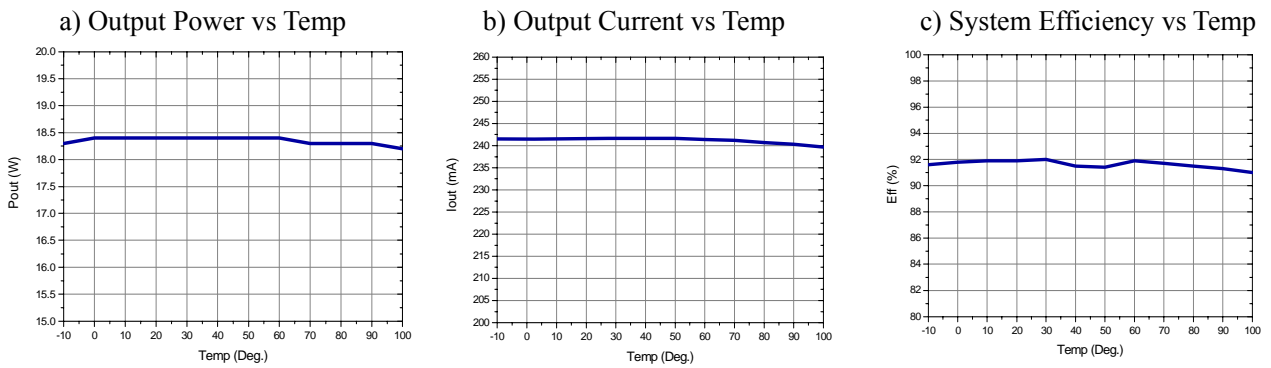
◆ TYPICAL PERFORMANCE CHARACTERISTICS

Following is the test data of BP2808 Demo:

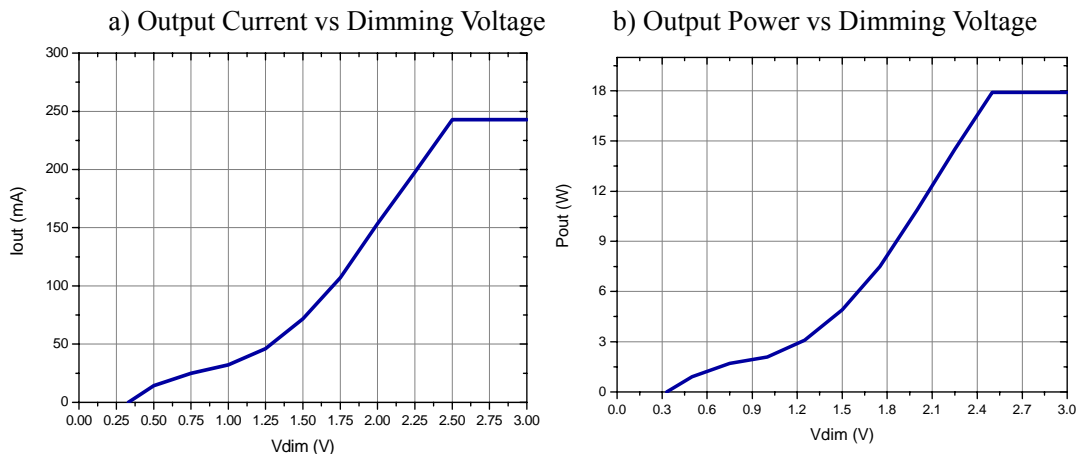
1. System Performance vs Input voltage



2. System Performance vs Temperature



3. System Performance vs Dimming



Package

