BP1601

Step-up Constant Current LED Driver

Description

BP1601 is a step-up DC/DC converter designed to drive high brightness LED from 4.5V to 24VDC input voltage . Typically in 12VDC input voltage, up to seven 1W LED strings is able to be drived.

BP1601 works in current mode to control LED current, it set the LED current by sense resistor, this low-side sensing strategy is used to minimize the power dissipation and improve system efficiency.

BP1601 detects the OV pin voltage to provide open circuit protection.

The BP1601 includes under-voltage lockout, current limiting and thermal overload protection preventing damage in the event of an output overload.

BP1601 is assembled in SOP-8PP package, which provides excellent heat dissipation and thermal performance.

Applications

- Solar LED lighting
- Portable LED lighting
- LCD LED backlight

Features

- 4.5V~24V input voltage range
- Up to seven 1W LED strings is drived when V_{IN}=12V
- Higher than 90% efficiency
- Less than 1uA MOSFET leakage current
- 200mV current sense voltage
- 1A current limit
- Soft start
- Input under-voltage lockout
- Output over-voltage protection
- Internal over-temperature protection
- PWM and analog Dimming

Typical Application

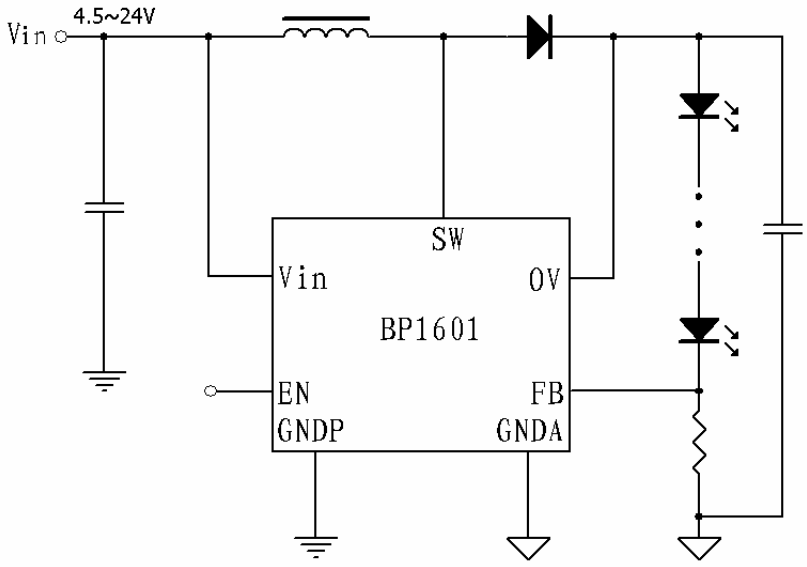
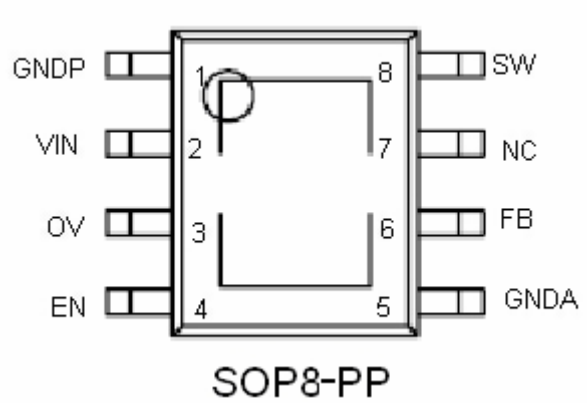


Figure 1 typical application circuit

Pin configuration



Pin Description

Pin No.	Pin Name	Description
1	GNDP	Power ground
2	V_{IN}	Power supply of the chip, connect a bypass capacitor to ground as close as possible
3	OV	Output voltage detect. Protect the chip and system while LED is open.
4	EN	PWM and analog dimming input. While connecting to logic" high" , chip is enabled; While connecting to logic" low" more than 3ms,chip is disabled; Be logic low while left floating. The PWM dimming signal frequency should be higher than 20KHz.
5	GNDA	Signal ground
6	FB	Output current Feedback. Set the LED current by detecting the voltage in the sense resistor. The voltage threshold is 200mV
7	NC	Not connect
8	SW	Drain of internal MOSFET

Ordering Information

Order Number	Package	Operating Temperature Range	Packing Method	Marking
BP1601EESO8	SOP8-PP	-40 °C to 85 °C	Tape and Reel 2,500 units	BP1601 xxxxxx xxx

Absolute Maximum Ratings (Note1)

Symbol	Parameters	Value	Unit
SW	Drain of internal MOSFET	-0.3~36	V
FB	Output current Feedback	-0.3~6	V
EN	Chip Enable voltage, dimming input voltage	-0.3~6	V
OV	Output voltage detect	-0.3~36	V
V_{IN}	Power supply voltage	-0.3~25	V
P_{DMAX}	Power dissipation (note2)	0.3	W
PTR	Thermal resistance, SOP8-PP（θ_{JA}）	110	°C /W
T_J	Operating temperature	-40 to 150	°C
T_{STG}	Storage temperature	-55 to 150	°C
	ESD Susceptibility (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 define 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*

Electrical Characteristics (note4, 5) (V_{IN}=12V, T_A=25 °C unless otherwise stated)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Power supply						
V_{IN}	Input Voltage		4.5		24	V
V_{UVLO}	Under voltage lock out	V_{IN} falling		3.9		V
$V_{UVLO, HYS}$	UVLO hysteresis	V_{IN} rising		200		mV
Feedback						
V_{FB}	Feedback voltage threshold		190	200	210	mV
I_{BIAS}	Feedback bias current			0.05	1	uA
Operation Current						
I_{OFF}	Shut down current	V_{SW-ON} =0V		0.1	1	μA
I_{STBY}	Quiescent current	V_{FB}=0.5V		100		μA
I_{OP}	Operation current			1		mA
F_{SW}	Switch frequency		0.6	0.8	1	MHz
D_{MAX}	Maximum duty cycle	V_{FB}=0V	85	95		%
Chip Enable						
V_{EN_H}	"EN" logic high voltage		2			V
V_{EN_L}	"EN" logic low voltage				0.4	V
R_{EN}	Pull-down resistance			300		KΩ
MOSFET						
R_{ON}	Switch "ON" resistance			0.8		Ω
I_{LIMIT}	Maximum MOSFET current	Vin=5V		1		A
I_{LEAK}	Switch leakage current			0.01		μA
Over voltage protection						
V_{OV}	Over-voltage detect Threshold		25	28		V
V_{OV_HYS}	Over-voltage detect Hysteresis			6		V
Soft start						
t_{SST}	Soft start time			300		Us
Over temperature protection						
T_{SD}	Thermal shutdown Threshold	T_{SD}		150		℃
T_{SD}-hys	Thermal shutdown Hysteresis	T_{SD}-hys		30		℃

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*

Block Diagram

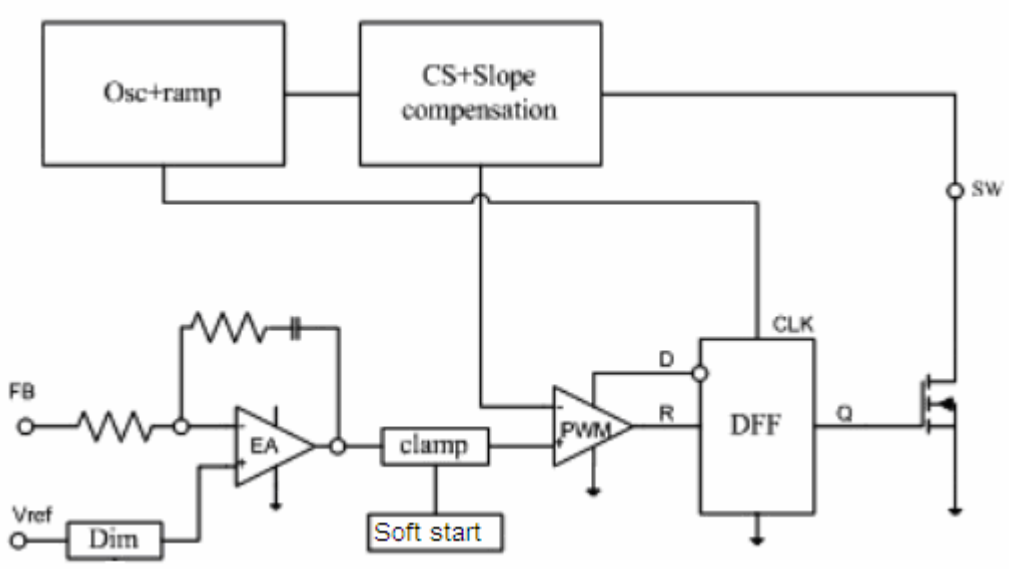


Figure 2 block diagram

Operation

The BP1601 uses a constant frequency, peak current mode boost regulator architecture to regulate the strings of white LEDs. Refer to the block diagram in Figure 2 for details.

At the start of each oscillator cycle the FET is turned on through the control circuitry. To prevent sub-harmonic oscillations at duty cycles greater than 50%, a stabilizing ramp is added to the output of the current sense amplifier and the result is fed into the positive input of the PWM comparator. When this voltage equals the output voltage of the error amplifier the power FET is turned off. The voltage at the output of the error amplifier is an amplified version of the difference between the 200mV reference voltage and the feedback voltage. In this way the peak current level keeps the output in regulation. If the feedback voltage starts to drop, the output of the error amplifier increases. This results in more current flowing through the power FET, thus increasing the power delivered to the output.

Application Note

Set the LED current

The average current of LED is determined by the value of the external current sense resistor (R_{CS}) connected between V_{FB} and GND and is given by:

$$I_{OUT}=200mV/R_{cs}$$

Rcs is recommended to choose 1% accuracy resistor with enough power tolerance and good temperature characteristic to ensure stable output current.

Inductor selection

Recommended inductor values for the BP1601 are in the range 10uH~22uH. The chosen coil should have a saturation current 30% higher than the peak output current.

Input capacitor selection

The input cap is used to bypass the power supply noise and spike, 2.2uF X7R ceramic capacitor is recommended.

Output capacitor selection

The output capacitor affects the stability of the system and output voltage ripple. We recommend 2.2uF X7R ceramic capacitor.

Diode selection

For maximum efficiency and performance, the rectifier (D1) should be a fast Schottky diode.

LED open protection

Open circuit protection will shut off the BP1601 if the output voltage rises too high when the OV pin is tied to the output. If the load is open, the FB voltage is zero, the chip works in the maximum duty cycle. Since the inductor have no path to demagnetize, the output voltage will increase continuously. The OV pin detects the output voltage, once it is higher than 28V for several cycles, the MOSFET is shut down; after some time, the MOSFET is turned on if the OV pin voltage goes back to the normal range. This process recycles until the fault condition is removed.

Over temperature protection

The thermal shutdown circuitry detects the BP1601 die temperature. The typical over temperature threshold is 150°C with 30°C hysteresis. When the die temperature rises above this threshold the IC is disabled, it remains disabled until the die temperature falls to 120°C,at which point the IC restart.

Analog and Digital Dimming

1.Analog Dimming

The analog dimming is shown as figure below: the LED current is adjusted by the DC voltage, If the DC voltage increase, the voltage drop on the R2 increase，that cause the voltage drop on the R1 decrease ,which lead to a smaller LED current. If the DC voltage decrease，the LED current increase.

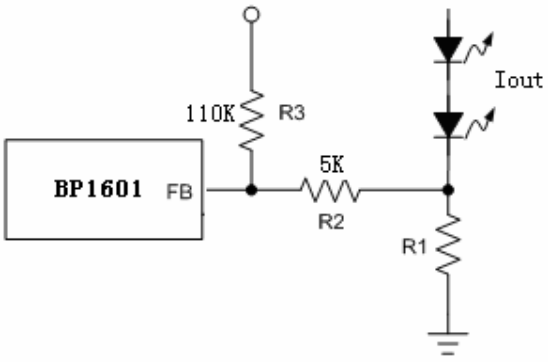


Figure 3

2.PWM dimming

A Pulse Width Modulated (PWM) signal with duty cycle D_{PWM} can be applied to the EN pin. When the EN pin is logic “high”, the output current is the set value; while the EN pin is logic “low”, the output

current is zero. As a result, the average current is in proportion to the Duty cycle $D_{PWM.}$

PCB layout

Good PCB layout is critical to system performance. Several of skills is recommended to be used in the layout:

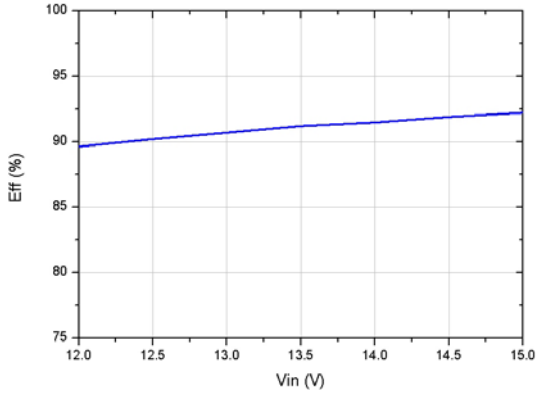
1 Increase the GND plane area to decrease the noise decoupling between signal route, it also bypass some high frequency noise.

2 We recommend not to share the feedback resistor ground return with other GND route to get a clean feedback signal. The feedback resistor should be connected to the GND pin directly.

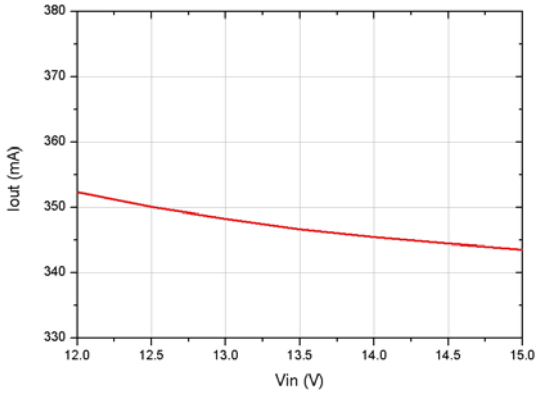
3 The high frequency loop area should be kept as small as possible. SW pin gets sharp rising edge and falling edge ,the trace to SW pin is required to be as short as possible to get better EMI result.

Typical Performance Characteristics （Test condition: 7*1W LED ,L=10uH，T_A=25℃）

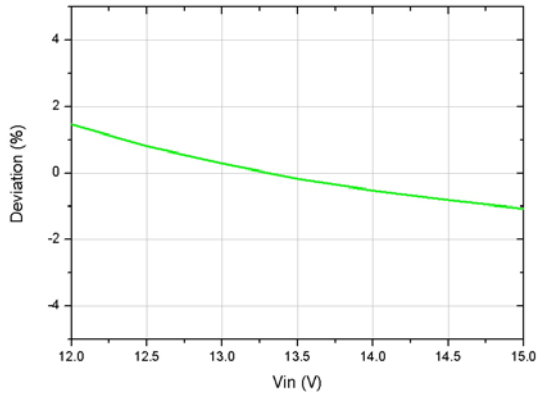
1）efficiency VS input voltage



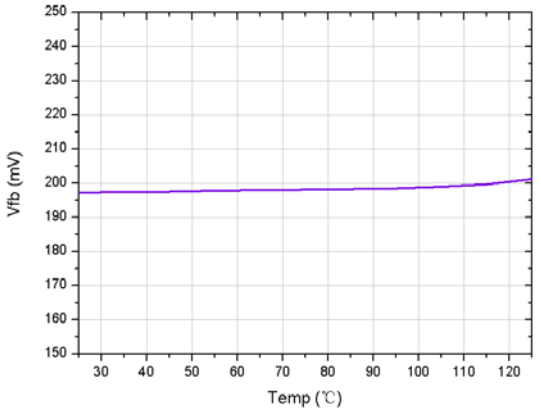
2) output current VS input voltage



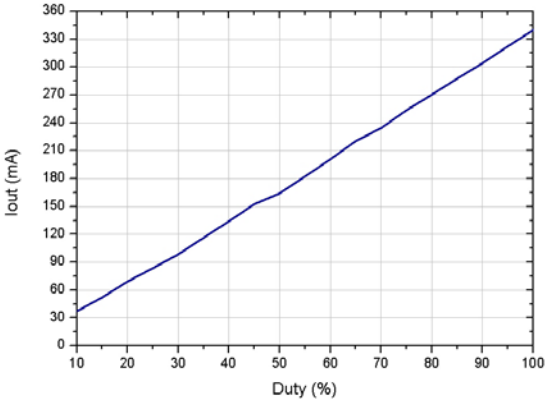
3) Output current variation with Supply Voltage



4) Vref voltage with environment temperature



5)PWM dimming curve（Iout=350mA）



Typical Application Circuit

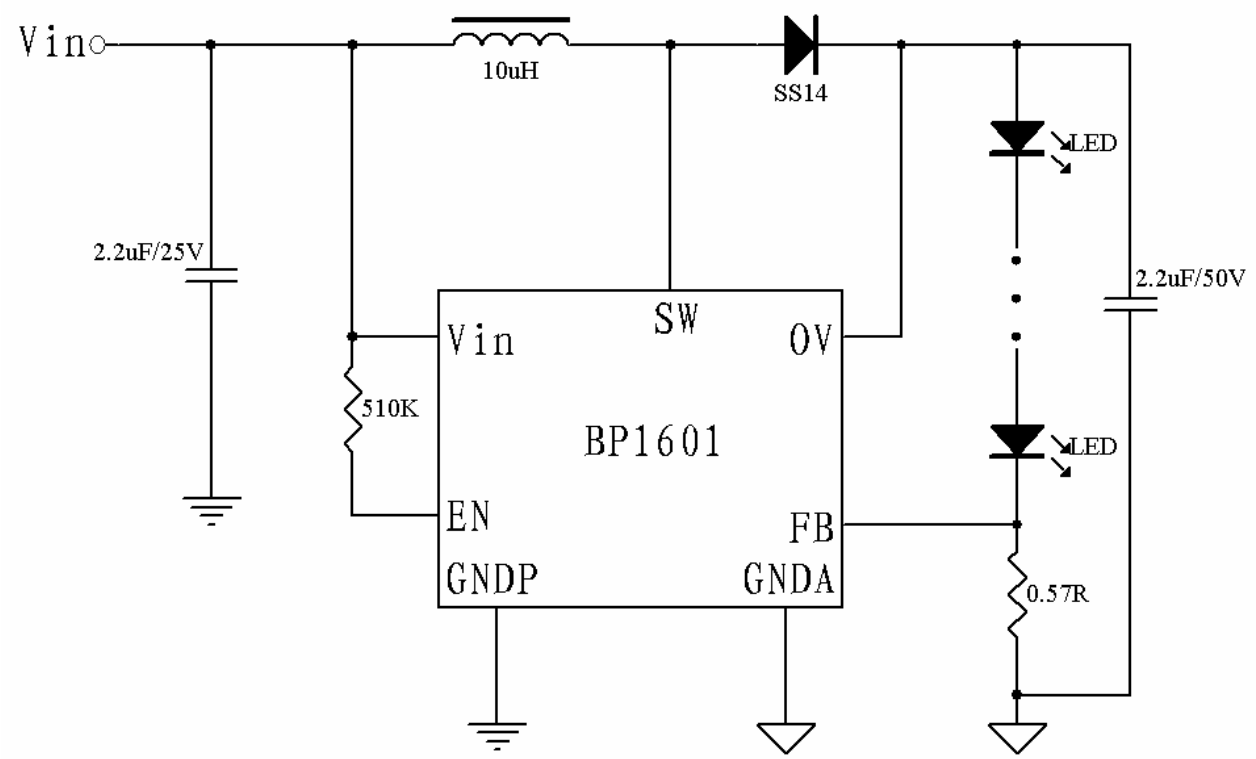
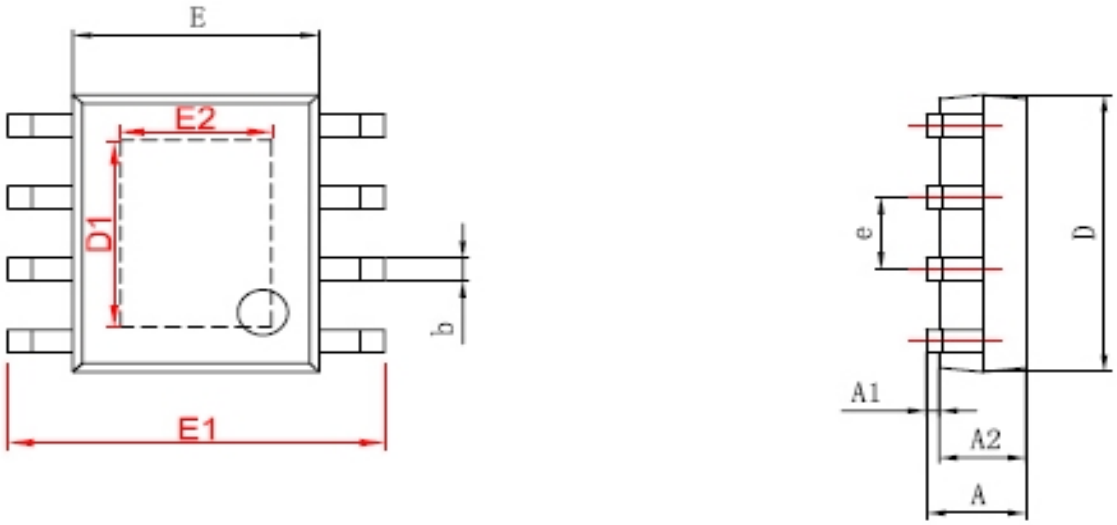
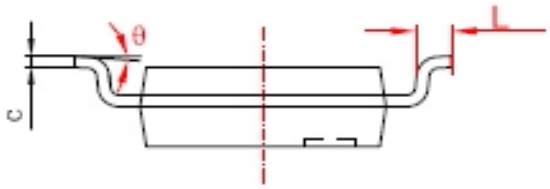


Figure 4 typical application circuit(7*1W)

Package Information

SOP8-PP(EXP PAD) PACKAGE OUTLINE DIMENSIONS





字符	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	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
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°