BYD Microelectronics Co., Ltd.

BF1004

ON/OFF LED Driver IC

General Description

The BF1004 is a high performance AC/DC on/off LED driver which uses PFM method to build DCM fly-back power supplies. It operates in primary-side sensing and regulation while removing the need of secondary feedback circuitry. The device operates in PFM in CC mode and ON-OFF in CV mode. Particular inductance compensation mode without more external components can achieve a high tight output current regulation.

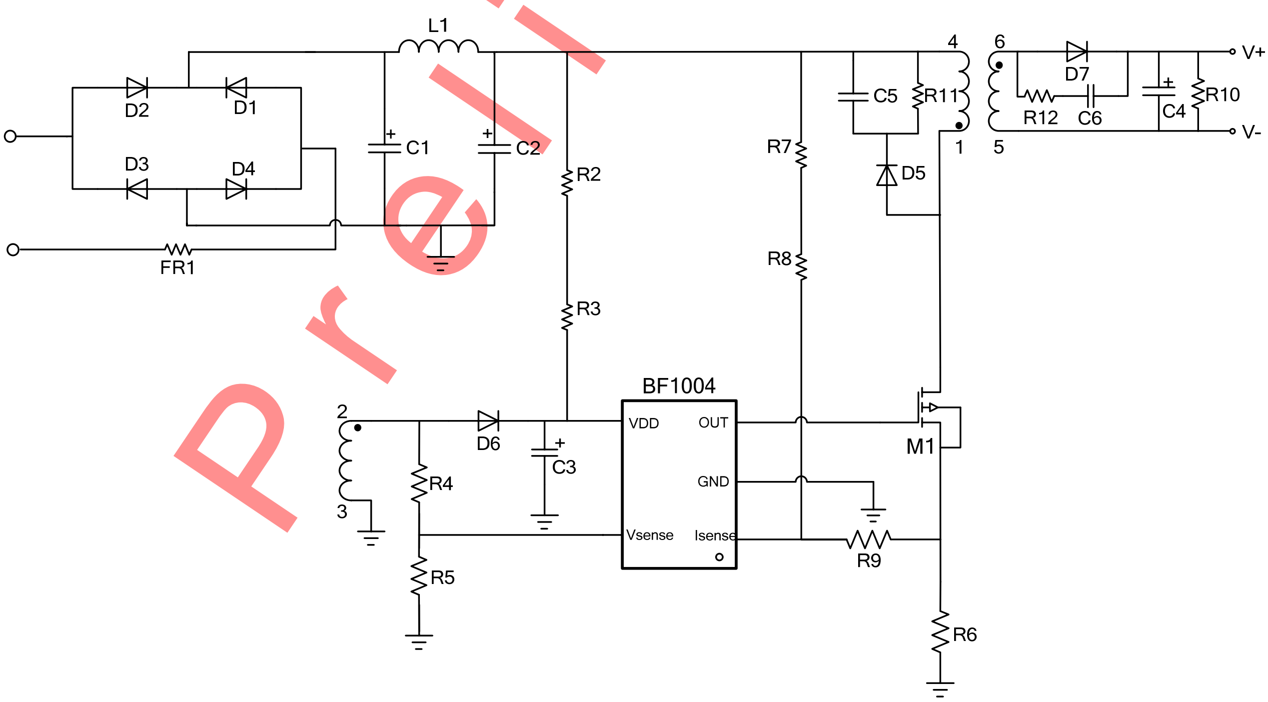
Application

- LED lampion
- LED bulb (E14、E27 etc)
- LED bedlamp

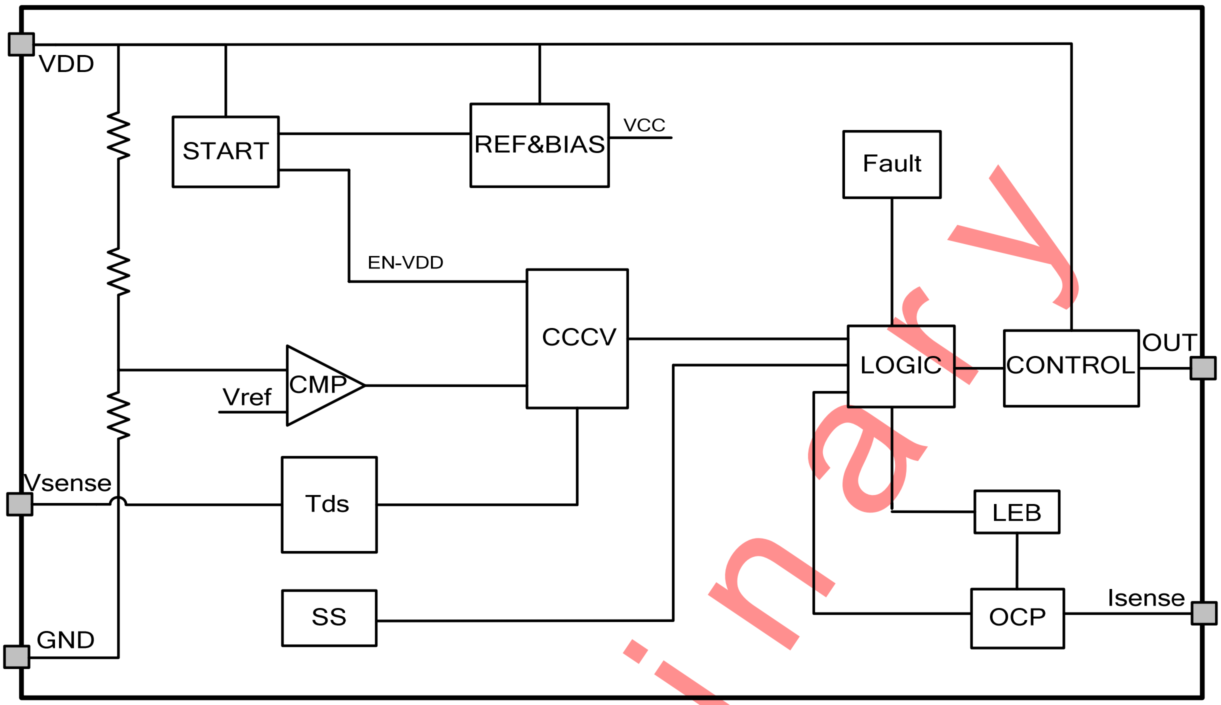
Features

- Typical 5% output Current Accuracy
- Constant frequency start-up mode accelerate start-up process
- Eliminates Opto-coupler and TL431
- Built-in Short Circuit Protection, VDD Over Voltage Protection
- Cycle-by-Cycle Current Limiting
- Built-in Leading Edge Blanking (LEB)
- VDD Under Voltage Lockout with Hysteresis (UVLO)
  - Typ.16.5V start-up
  - Typ.8.0V shut-down
- Small SOT23-5 Package

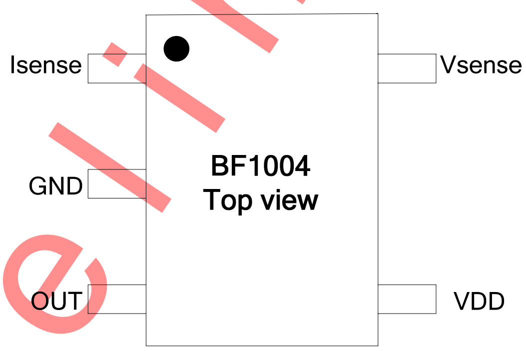
Typical Application



Block Diagram



Package Type



Pin Definition

Pin number	Pin name	Pin description
1	Isense	Current sense input.
2	GND	Ground.
3	OUT	Gate drive output for the external power MOS switch.
4	VDD	Power supply.
5	Vsense	Voltage sense input from the auxiliary winding.

Electrical Characteristic

(TA = 25°C, if not otherwise noted)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Supply Voltage						
Start-up Current	I_{dd}	VDD=14V		18	22	μA
Operation Voltage	V_{OV}			18		V
Operation Current	I_{OC}			250	300	uA
Turn-on Threshold Voltage	V_{ON}		14.5	16.5	18.5	V
Turn-off Threshold Voltage	V_{OFF}		6.5	8	9.5	V
CC/CV Mode Change Voltage	V_{CCCV}		20	21	23	V
Oscillator						
Duty Cycle	T_{ds}/T		49	50	51	%
Max Frequency	Fmax		60	66	72	KHz
Current Sensing						
Leading Edge Blanking	T_{LEB}		350	400	450	ns
Current Sense Detection Voltage	Vocp_max		0.485	0.500	0.515	V
Gate Driver Output						
Output Delay Time	T_d			150		ns
Output Rising Time	Tr	VDD=18V,CL=1nF		200		ns
Output falling Time	Tf	VDD=18V,CL=1nF		50		ns

Absolute Maximum Ratings

Item	Symbol	Value	Unit
VDD pin input voltage	VDD	20	V
Lead temperature	T_L	260	℃
SENSE pin input voltage	V_{SENSE} I_{SENSE}	7	V
Power Dissipation	P_D	400	mW
Operating Junction Temperature	T_J	-40 to +125	℃
Storage Temperature Range	T_{STJ}	-55 to +150	℃

Attention: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Operation Description

The BF1004 uses PFM with a constant factor between the demagnetization time and the operate cycle time to regulate the output current. Particular inductance compensation mode without more external components can achieve a high tight output current regulation.

- **Start-up Current and Constant Frequency Start**

  The BF1004 is designed to have a low start-up current so that VDD can be charged up above the UVLO threshold and starts up quickly. After start-up, BF1004 will operate in a constant frequency (Typ.25KHz) until the output Voltage up to a certain value, so that the output can set up quickly.

- **CC/CV Operation Mode**

  The switching frequency of BF1004 is adaptively controlled according to the load conditions and the operation modes. For flyback operating in DCM, the maximum output power is given by:

$$Pout = 0.5 * Lp * Fsw * Ip * Ip \qquad (1)$$

(Lp: the inductance of primary winding; Ip: the peak current of primary winding)

Refer to the equation 1, the change of the primary winding inductance results in the change of the maximum output power and the constant output current in CC mode. To compensate the change from variations or primary winding inductance, the switching frequency is controlled by an internal loop, the relation is given by:

$$Fsw = 1/(2 * Tds) \qquad (2)$$

(Tds: The demagnetization time of secondary winding)

Since Tds is proportional to the inductance, as a result, the product Lp and Fsw is constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes .The output current can be calculated by the following expressions:

$$Iout = 0.5 * \frac{Tds}{T} * \frac{Np}{Ns} * Ip \qquad (3)$$

(Np: Primary winding turns of the transformer; Ns: Secondary winding turns of the transformer.)

As the voltage of the VDD pin approaches to Vcccv from the CC operation mode, the power supply smoothly switches to operate in CV portion. During CV operation, the IC adjusts the MOS switching frequency to provide a constant output voltage. The output voltage can be calculated by the following expressions:

$$Vout = [(20.5 + VD6) * \frac{Ns}{Na}] - VD7 \qquad (4)$$

(Ns: Secondary winding turns of the transformer; Na: Auxiliary winding turns of the transformer.)

- **Cycle-by-Cycle Current limit**

The current limit circuit senses the primary current form the voltage on the sensing resistor cycle by cycle. When the voltage exceeds the internal threshold, the power MOS will turn off immediately.

- Voltage Protection Function

The BF1004 includes such a function that protect against output over-voltage and under-voltage, which could be monitored by VDD pin. If the voltage at VDD pin exceeds the over-voltage threshold, the external power MOS will be turned off immediately and the controller will restart. Once VDD drops below the UVLO threshold, the controller will reset itself and go into a new start cycle. The controller will continue the start cycle until the error condition is removed.

Test Circuits

(1) Start-up current consumption (circuit 1)

Test Condition:

Connect Isense pin to ground, make the OUT pin floating and set V2=0.8±0.03V,R1=10Kom.

Test Method:

Set V1=5±0.03V with 1ms delay time.

Keep V1 powered, increase V1 to 14±0.03V, the current A1 flowing into VDD is the current consumption.

(2) Hysteresis start-up (circuit 1)

Test Condition:

Connect Isense pin to ground, make the OUT pin floating and set V2=0.8±0.03V,R1=10Kom.

Test Method:

Set V1=5±0.03V with 1ms delay time.

When V1 increases over V_{X1}, the IC starts to work normally, and only when V1 decreases under V_{X2}, the IC stops working and moves into standby mode.

V_{X1} is the voltage V1 when the output (the OUT pin) frequency changes from (0±0.2KHZ) to (25±6KHZ).

V_{X2} is the voltage V1 when the output (the OUT pin) frequency changes from (25±6KHZ) to (0±0.2KHZ).

(3) Over current protection detection voltage (circuit 2)

Test Condition:

Make the OUT pin floating and set V1=19±0.03V, V2=0.8±0.03V,R1=10Kom.

Test Method:

Set V3=0±0.03V with 1ms delay time.

The over current protection detection voltage is the voltage V3 when the output (the OUT pin) frequency changes from (25±6KHZ) to (0±0.2KHZ)

(4) CC/CV mode transforming voltage (circuit 1)

Test Condition:

Connect Isense pin to ground, make the OUT pin floating and set V2=0.8±0.03V,R1=10Kom.

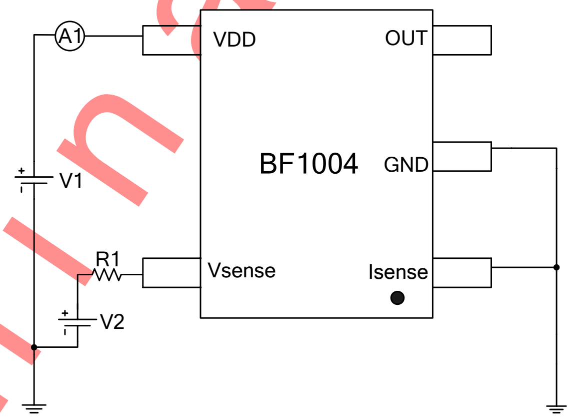
Test Method:

Set V1=5±0.03V with 1ms delay time.

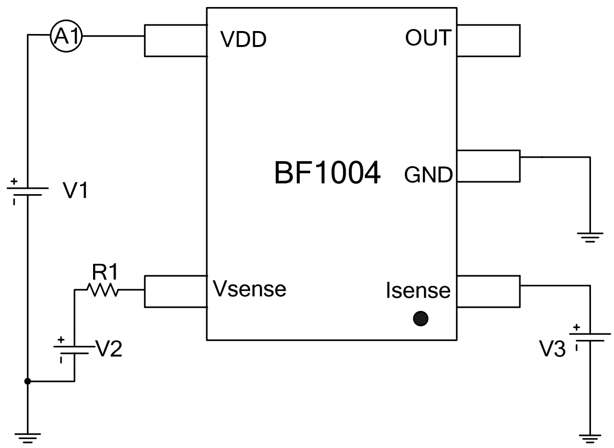
Keep V1 powered, increase V1 to 19±0.03V, the IC starts to work normally, the output (the OUT pin) frequency changes from (0±0.2KHZ) to (25±6KHZ).

Then increase V1 to V_{CVX1}, the output (the OUT pin) frequency changes from (25±6KHZ) to (0±0.2KHZ).

V_{X1} is the CC/CV mode transforming voltage



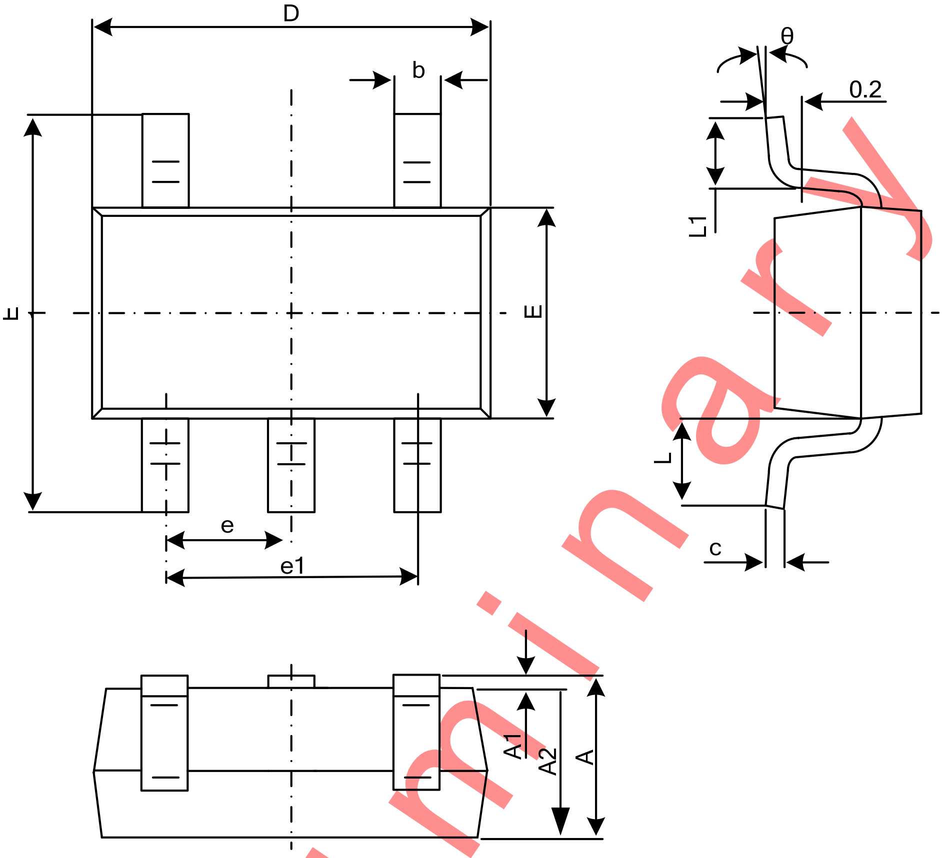
Circuit1: For testing current consumption, Hysteresis start-up



Circuit2: For over current protection detection

Package Outline

SOT23-5



Symbol	Dimensions In Millimetres		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

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