OB3338

Dimmable High PF, Low THD Offline LED Controller

GENERAL DESCRIPTION

OB3338 is a dimmable offline LED lighting controller with high power factor, low THD and high constant current (CC) precision. It can achieve low system cost for an isolated lighting application by primary side control in a single stage converter.

The proprietary CC control scheme is used and the system can achieve high power factor with constant on-time control scheme. Quasi-resonant (QR) operation and clamping frequency greatly improves the system efficiency. The advanced start-up technology is used to meet the start-up time requirement (<0.5s). The constant output current is compensated for tolerance of transformer inductance variation. And the line compensation is built in OB3338 for high precisely constant output current control.

OB3338 offers a dimmable function, the LED current can be controlled by setting the duty cycle of PWM waveform into the DIM pin.

OB3338 offers comprehensive protection coverage with auto-recovery features including LED open loop protection, LED short circuit protection, cycle-by-cycle current limiting, built-in leading edge blanking, VDD under voltage lockout (UVLO), etc.

OB3338 is offered in SOP8 package.

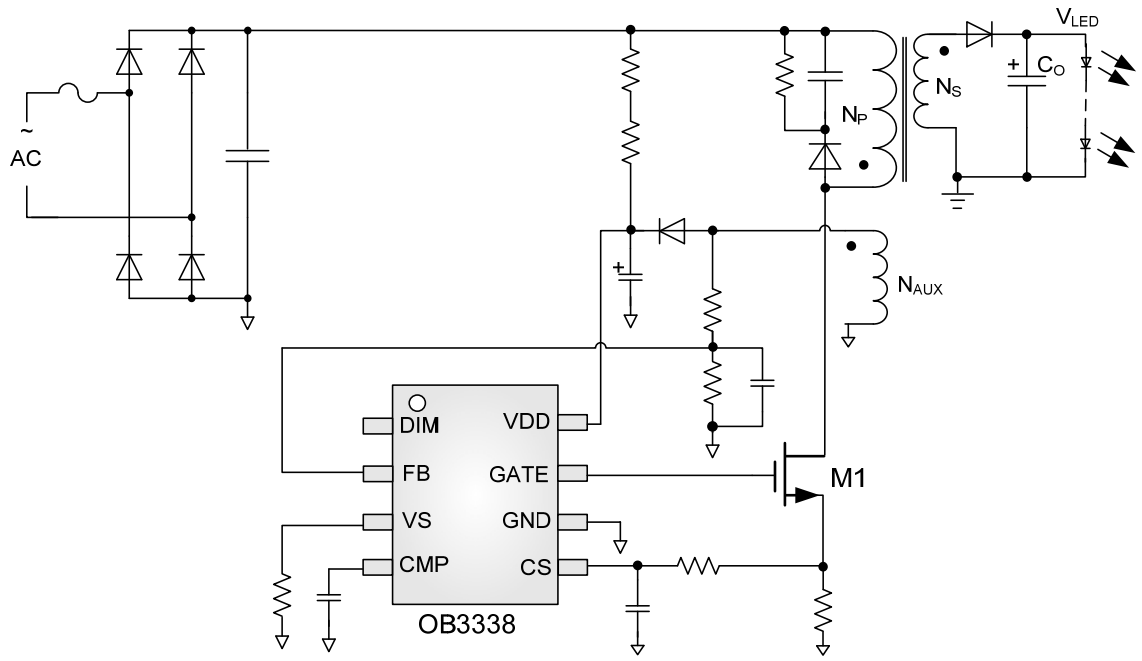
FEATURES

- Dimmable LED current control
- Primary-side sensing and regulation without TL431 and opto-coupler
- High precision constant current regulation at universal AC input
- High PF (>0.9)
- Low THD (<10%)
- Fast start-up
- Quasi-resonant operation
- Built-in line compensation
- LED short circuit protection
- LED open loop protection
- Cycle-by-cycle current limiting
- Built-in leading edge blanking (LEB)
- VDD under voltage lockout with hysteresis
- VDD over voltage protection
- Over temperature protection (OTP)

APPLICATIONS

- LED lighting

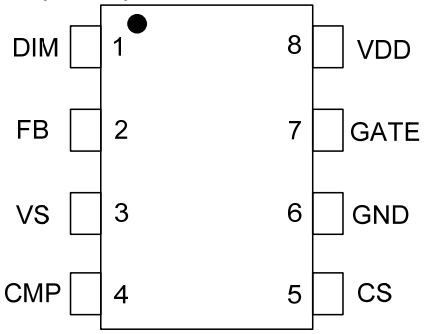
TYPICAL APPLICATION



GENERAL INFORMATION

Pin Configuration

The pin map is shown as below for SOP8.



Ordering Information

Part Number	Description
OB3338CP	8 Pin SOP, Halogen-free in Tube
OB3338CPA	8 Pin SOP, Halogen-free in T&R

Note: All Devices are offered in Halogen-free Package if not otherwise noted.

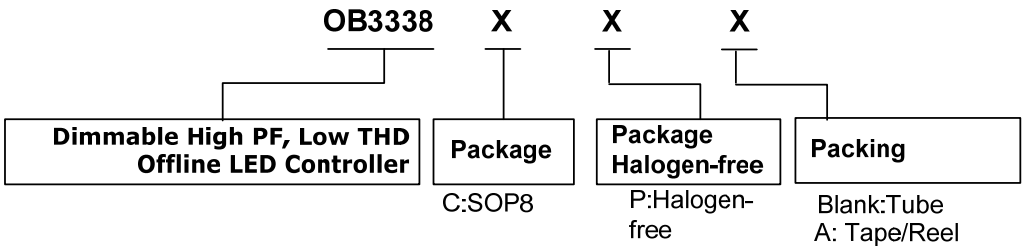
Package Dissipation Rating

Package	RθJA (℃/W)
SOP8	150

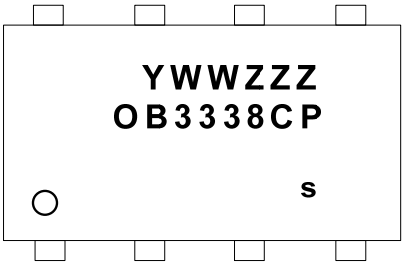
Absolute Maximum Ratings

Parameter	Value
VDD Voltage	-0.3V to 40V
GATE Voltage	-0.3V to 40V
CS/FB/DIM/VS/CMP Input Voltage	-0.3V to 7V
Min/Max Operating Junction Temperature T_J	-40℃ to 150 ℃
Min/Max Storage Temperature T_{stg}	-55℃ to 150 ℃
Lead Temperature (Soldering, 10secs)	260 ℃

Note: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.



Marking Information



Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

C: SOP8

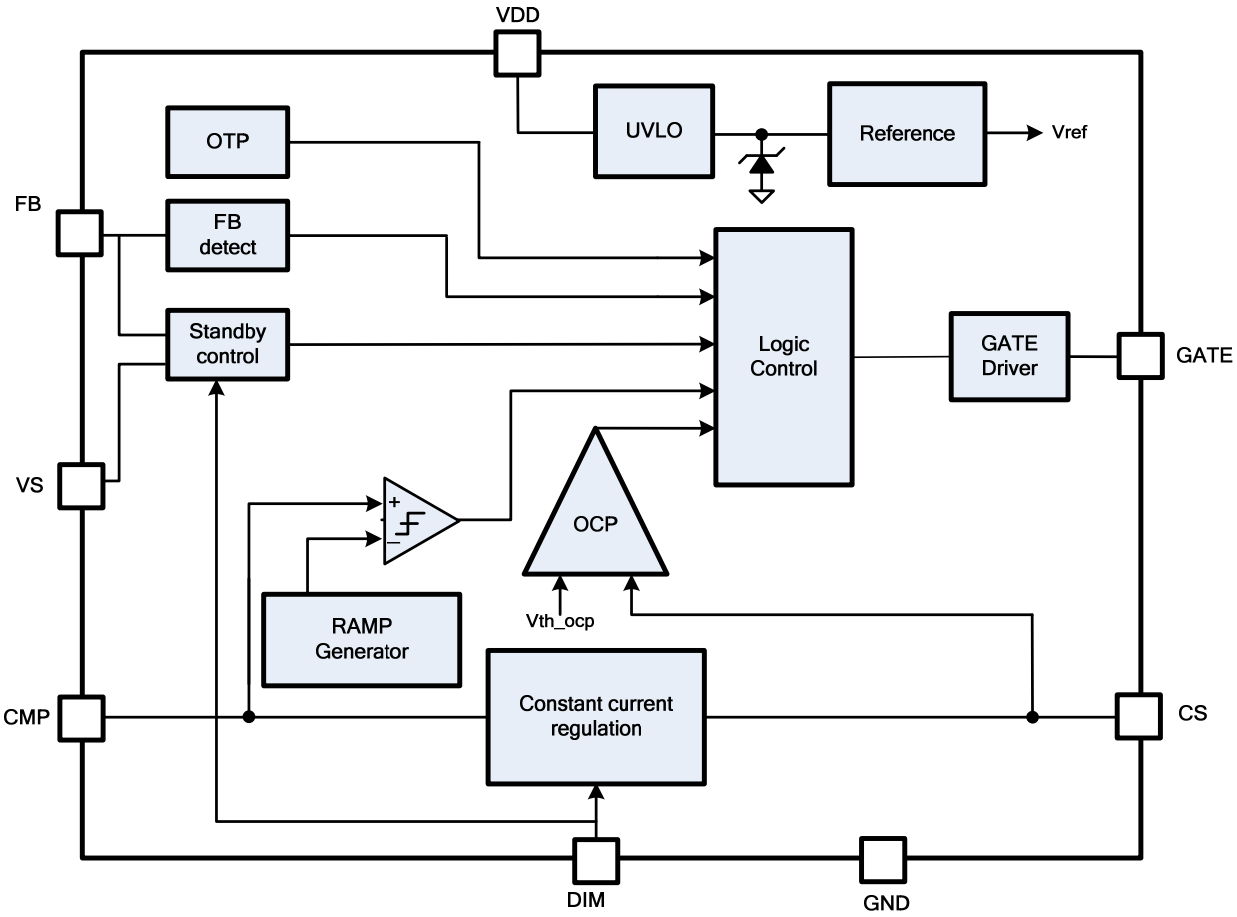
P:Halogen-free Package

s: Internal Code(Optional)

TERMINAL ASSIGNMENTS

Pin Num	Pin Name	I/O	Description
1	DIM	I	PWM dimming signal input. The LED current can be controlled by the duty cycle of the PWM waveform at the DIM pin. IC adopts DIM pin negative logic control.
2	FB	I	Voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage.
3	VS	I/O	Output voltage selection in standby mode.
4	CMP	I/O	Loop compensation pin. A capacitor is connected between CMP and GND.
5	CS	I	Current sensing terminal.
6	GND	P	Power Ground.
7	GATE	O	Gate driver output for power MOSFET.
8	VDD	P	Power supply Input.

BLOCK DIAGRAM



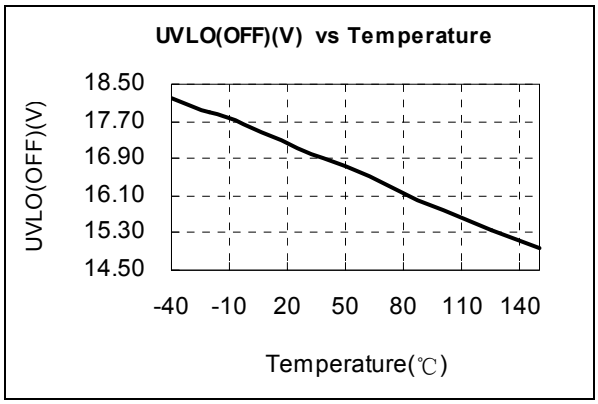
ELECTRICAL CHARACTERISTICS

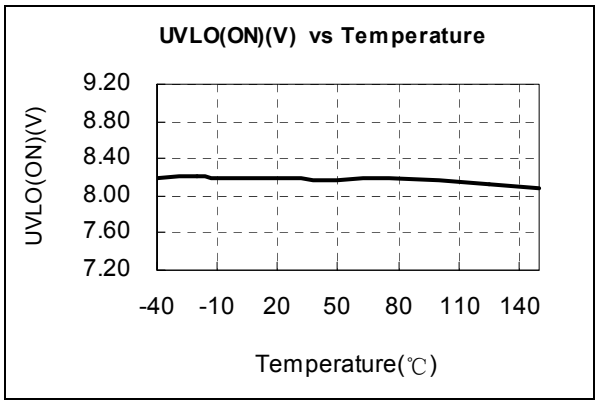
(TA = 25℃, VDD=20V, if not otherwise noted)

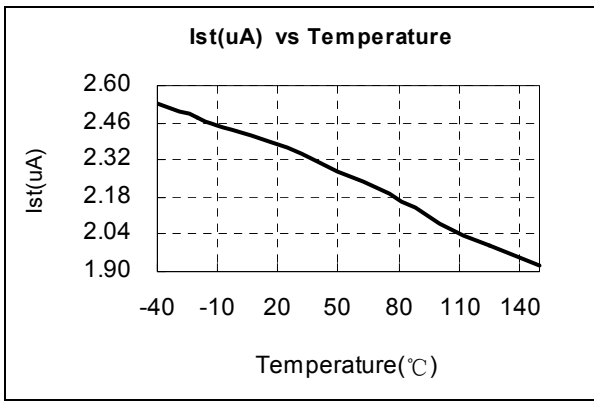
Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
Supply Voltage (VDD) Section						
$I_{start-up}$	Start up current	VDD=UVLO(OFF)-1V		3	7	uA
I_{op}	Operation current	VDD=20V, no loading		0.55	0.8	mA
UVLO(OFF)	VDD under voltage lockout exit		16	18	20	V
UVLO(ON)	VDD under voltage lockout enter		7	8	9	V
VDD_OVP	VDD Over Voltage Protection		30	32	34	V
Current Sense Input Section						
TLEB	Leading Edge Blanking time			0.4		us
Vth_ocp	Over Current Threshold	FB>0.45V	1.05	1.1	1.15	V
		FB<=0.45V		0.5		V
FB Input Section						
Vout_ovp	Output Over Voltage Protection		3.325	3.5	3.675	V
Vout_scp	Output Short Circuit Protection			0.45		V
I_FB	Maximum Sink current from FB				2	mA
QR Section						
Fmax	Maximum Clamping Frequency			100		KHz
Toff_max	Maximum Off Time			115		us
Toff_min	Minimum Off Time	CS>0.15V		2		us
		CS<=0.15V		0.5		us
Ton_max	Maximum On Time			25		us
Error Amplifier Section						
Vref	Error Amplifier Reference Voltage		0.196	0.200	0.204	V
Gm	Error Amplifier Transconductance			40		us
Vclamp_cmp	CMP Pin down_clamp Voltage			1.0		V
Dimming section						
$Vth_{DIM\ high}$	DIM logic high level		2			V
$Vth_{DIM\ low}$	DIM logic low level				0.8	V
f_{DIM}	DIM logic frequency		0.5		50	KHz
Vth_{FB_sdb}	FB voltage at Standby mode	VS is connected to GND by 200kohm resistor		1.2		V
		VS floating		1.5		V
		VS is connected to GND		1.8		V

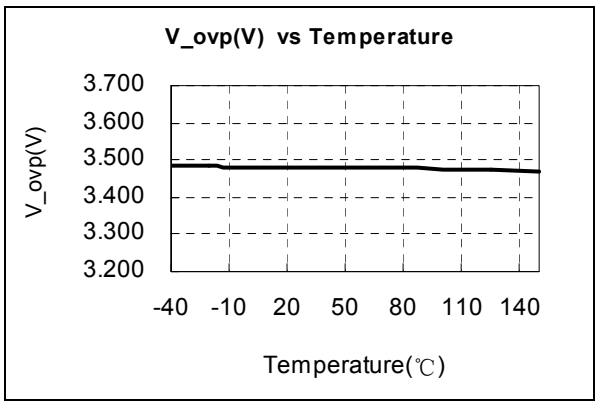
Gate Driver Section						
Vol	Output Low Level	Iout=10mA			1	V
Voh	Output High Level	Iout=10mA	6			V
Vclamp	Output Up-Clamping Voltage		10	12	14	V
Tr	Rising Edge Time	Cl=1nF		90		ns
Tf	Falling Edge Time	Cl=1nF		30		ns
OTP Section						
OTP	Over Temperature Protection			150		℃

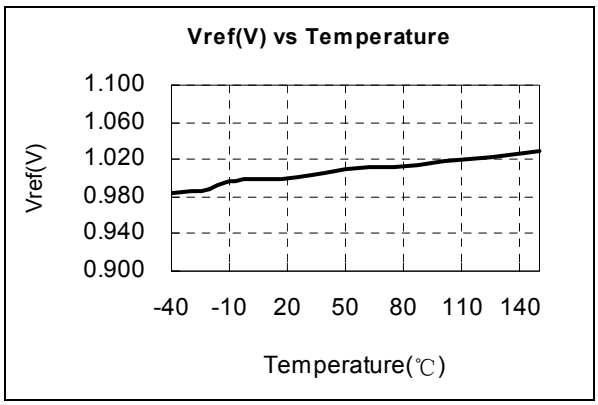
CHARACTERIZATION PLOTS

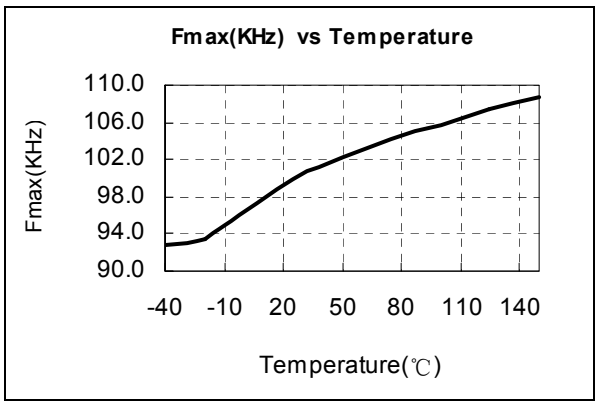












OPERATION DESCRIPTION

OB3338 is a dimmable primary-side-control and high power factor, low THD fly-back PWM controller specialized for LED lighting application. It operates in primary side sensing and regulation, thus opto-coupler and TL431 are not required. OB3338 works at Quasi-Resonant operation with maximum working frequency clamping, which can improve the efficiency of LED lighting system design.

- **Start up Control**

The advanced start-up technology is used in OB3338 to meet the start-up time requirement. Low start-up current is designed in OB3338 so that VDD could be charged up above UVLO threshold with small charging current.
During the startup, the capacitor at CMP pin is pulled up quickly. OB3338 operates at open loop and over-current protection is set cycle-by-cycle until it senses the output voltage by FB pin up to Vth_sdb (standby voltage) controlled by VS pin.

- **LED Constant Current Regulation**

The LED output current equals to the average of the output rectifier diode current. So the LED output current is related with the transformer peak current value and the transformer current discharge time. The transformer current discharge time is sensed through FB pin and the transformer peak current value is determined by internal reference voltage. A proprietary CC control block calculates LED output current through the CS pin peak current value and the transformer current discharge time. The output of the calculation is compared with an internal precise reference to generate an error voltage (Vcmp), which determines the turn-on time in voltage mode control. The LED output current can be approximated as:

$$I_{LED} = \eta \cdot \frac{N}{2} \cdot \frac{Vref}{R_{CS}} (1 - D)$$

η — The transformer coupling coefficient.
N — Turn ratio of primary side winding to secondary side winding.
Rcs — The sensing resistor connected between the MOSFET source and GND.
Vref — Internal reference voltage.
D — Duty cycle of the PWM waveform at DIM pin.

- **PFC and THD**

The duration of the turn on period ton is generated by comparing an internal fixed saw-tooth wave with the voltage on the CMP pin. During steady state operation, the voltage on the CMP pin Vcmp is slowly varying due to a large external capacitor connected at the CMP pin, therefore the turn on time ton is constant. In a fly-back topology, constant turn on time and quasi-resonant operation provide high power factor (PF) and low total harmonic distortion (THD).

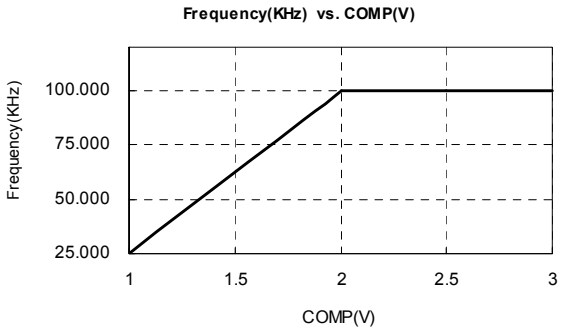
- **Standby control**

When DIM pin keeps in the logic high level state for about 20ms, OB3338 goes into standby mode. In standby mode, OB3338 sets over current protection threshold to 200mV (typical) and detects the voltage of FB pin. When FB voltage is above Vth_{FB_sdb} (FB voltage at standby mode) which is controlled by VS pin, gate shut down. After 10ms，OB3338 detects FB voltage again. The relationship between and VS pin is stated in the chart.

Vth_{FB_sdb}	VS is connected to GND by 200kohm resistor	1.2	V
	VS floating	1.5	V
	VS is connected to GND	1.8	V

- **Frequency decreasing control**

To achieve better current regulation under different line voltage and large duty cycle of DIM pin, OB3338 adopts frequency decreasing control technique which lowers the frequency according to the voltage of CMP pin. The relationship between clamping frequency and CMP is described as follows



- **Current Sensing and Leading Edge Blanking**

Cycle-by-Cycle current limiting (OCP) is offered in OB3338. The switching current is detected by a sense resistor connected between the CS pin and GND. An internal leading edge blanking circuit chops off the sense voltage spike at initial MOSFET on state due to snubber diode reverse recovery so that the external RC filter is no longer required. The current limit comparator is disabled at this blanking time and thus the external MOSFET cannot be turned off during this blanking time.

- **Quasi-Resonant Operation**

OB3338 performs quasi-resonant detection through FB pin by monitoring the voltage activity on the auxiliary windings in series with external resistors. When the stored energy of fly-back transformer is fully released to the output, the voltage at FB pin decreases. When FB pin voltage falls below 0.05V (typical), an internal FB Comparator is triggered and a new PWM switching cycle is initiated following the FB triggering.

- **Line compensation**

OB3338 provides internal line compensation to avoid using outside sensing devices. The compensated voltage is added to CS voltage cycle-by-cycle and LED output current is kept constant under different line voltage.

- **VDD Over Voltage Protection**

VDD is supplied with transformer auxiliary winding output. When VDD is higher than 32V (typical), VDD OVP protection is triggered and GATE is shut down, and the device enters power on startup sequence thereafter.

- **Thermal Shutdown**

OB3338 provides an on chip thermal shutdown protection. The IC will stop switching when the junction temperature exceeds the thermal shutdown temperature, typically 150 ℃

- **LED Short Circuit Protection**

When LED string is short, the positive plateau of auxiliary winding voltage is also near zero and the FB voltage is low. If the voltage at FB pin is lower than a threshold of approximately 0.45V (typical), the IC will work at minimum frequency and the threshold voltage of OCP is reduced to 0.5V (typical). The power dissipation is greatly reduced in this way.

- **LED Open Circuit Protection**

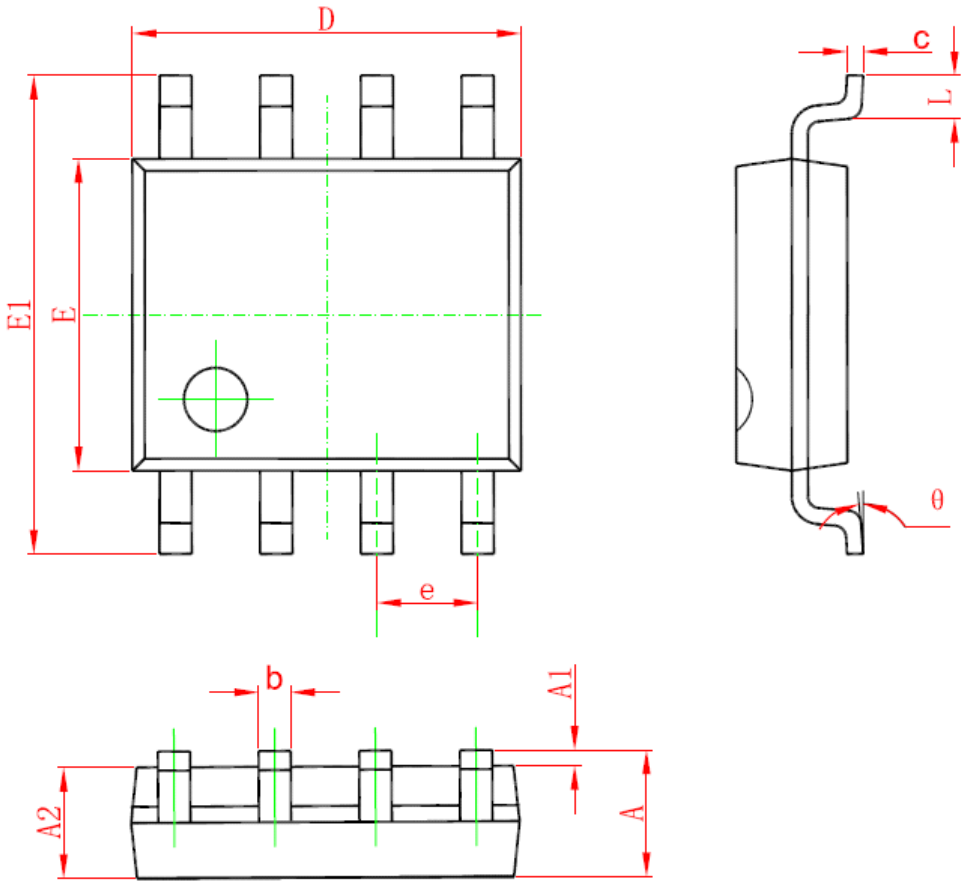
When the LED string open circuit happens, the positive plateau of auxiliary winding voltage increases and the FB pin voltage is high. If the voltage at FB pin is higher than a threshold of approximately 3.5V (typical), the IC will shut down and enter power on startup sequence thereafter.

- **Gate Driver**

The GATE pin is connected to the gate of an external power switch. An internal 12V (typical) clamp is added for MOSFET gate protection at high VDD voltage. When VDD voltage drops below UVLO (ON), the GATE pin is internally pulled low to maintain the off state.

PACKAGE MECHANICAL DATA

7/8-Pin Plastic SOP (SOP7/8)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	4.700	5.150	0.185	0.203
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°

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