

## GENERAL DESCRIPTION

OB3655x is an offline LED lighting controller with 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. It significantly simplifies the LED lighting system design by eliminating auxiliary winding.

The system uses the 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 and load compensation are built in OB3655x for high precisely constant output current control.

OB3655x 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.

OB3655x is offered in DIP8/EASOP6/SOP8 package.

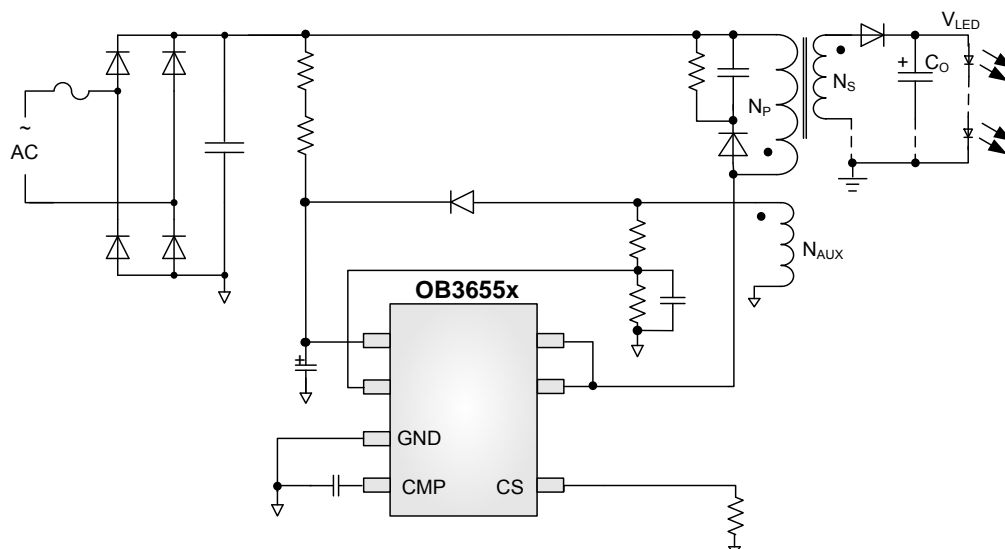
## FEATURES

- High precision constant current regulation at universal AC input
- Fast start-up ( $<0.5s$ )
- Primary-side sensing and regulation without auxiliary winding
- Low system cost and high efficiency
- Quasi-resonant operation
- Programmable CC regulation
- Built-in primary winding inductance 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)
- Thermal fold-back control

## APPLICATIONS

- LED lighting

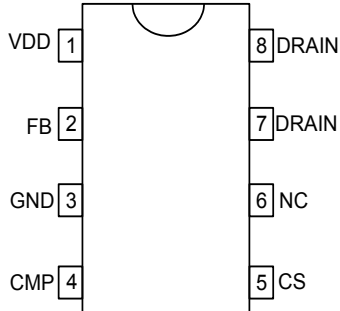
## TYPICAL APPLICATION



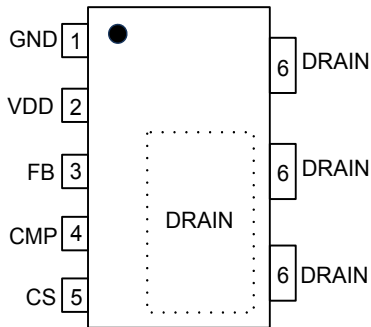
### GENERAL INFORMATION

#### Pin Configuration

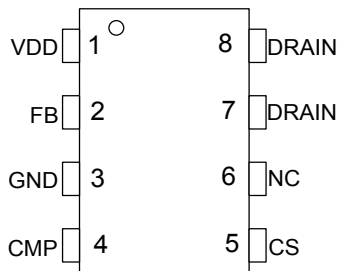
##### DIP8



##### EASOP6



##### SOP8



#### Package Dissipation Rating

Package	R $\theta$ JA (°C/W)
DIP8	75°C/W
EASOP6	68°C/W
SOP8	90°C/W

#### Ordering Information

Part Number	Description
OB3655TAP-H	DIP8, Halogen-free in Tube
OB3655TAP	DIP8, Halogen-free in Tube
OB3655PCQP-H	EASOP6, Halogen-free in Tube
OB3655PCQPA-H	EASOP6, Halogen-free in T&R
OB3655PCP-H	SOP8, Halogen-free in Tube
OB3655PCPA-H	SOP8, Halogen-free in T&R
OB3655NCP-H	SOP8, Halogen-free in Tube
OB3655NCPA-H	SOP8, Halogen-free in T&R

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

#### Recommended Operating Ratings

Parameter	Value
Body Surface Max.	135°C

#### Absolute Maximum Ratings

Parameter	Value
DRAIN Voltage	-0.3 to Bvdss
VDD Voltage	-0.3 to 40V
CS Input Voltage	-0.3 to 7V
FB Input Voltage	-0.3 to 7V
CMP Voltage	-0.3 to 7V
Min/Max Operating Junction Temperature T <sub>J</sub>	-40 to 150 °C
Min/Max Storage Temperature T <sub>stg</sub>	-55 to 150 °C
Lead Temperature (Soldering, 10secs)	260 °C

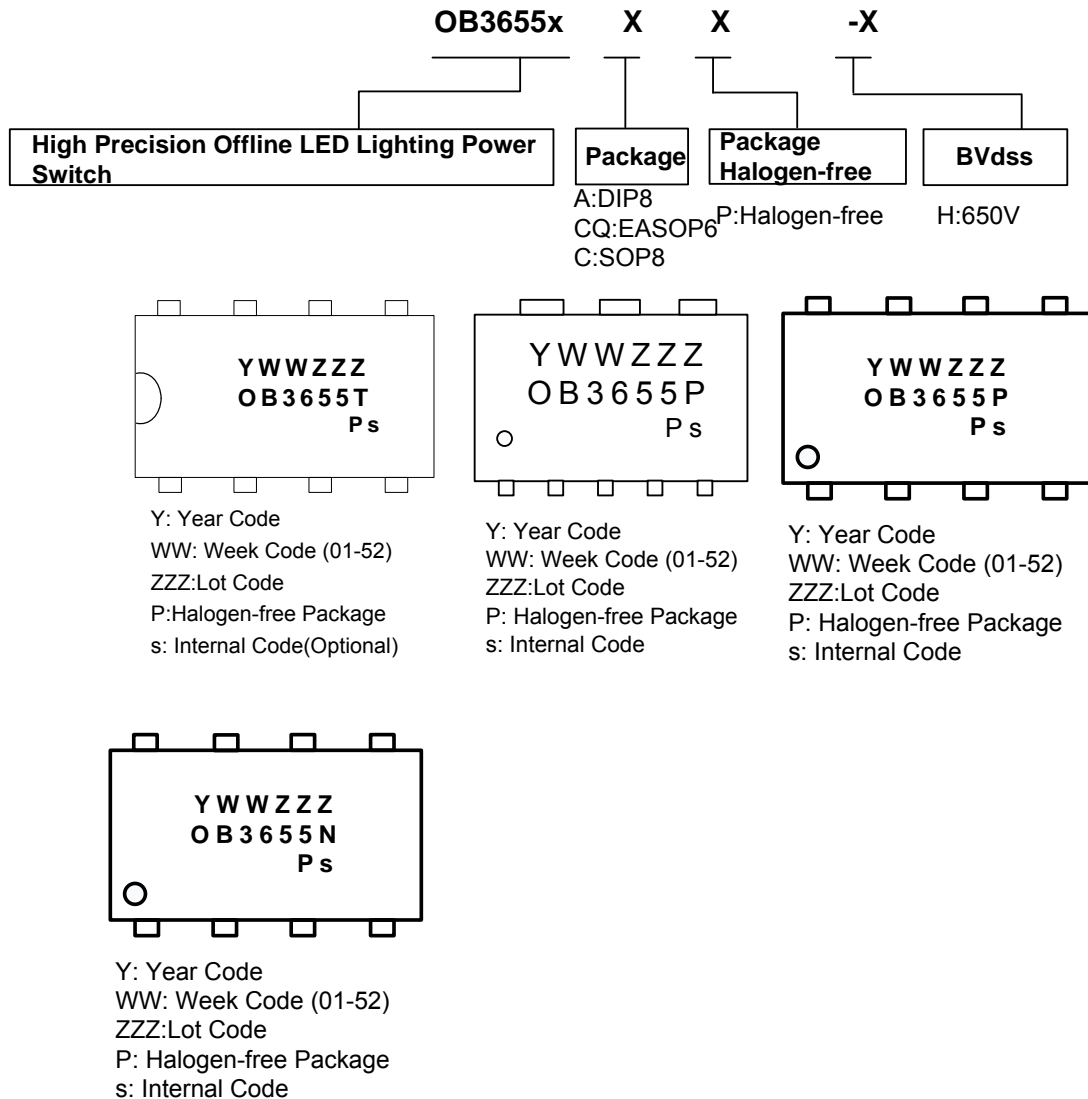
**Note:** Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure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

#### Output Power Table

Product	400Vdc±20%
	Open Frame
OB3655TAP-H	45W
OB3655TAP	45W
OB3655PCQP-H	24W
OB3655PCP-H	18W
OB3655NCP-H	16W

**Notes:** Maximum practical continuous power in an open frame design with sufficient drain pattern as a heat sink, at 50°C ambient and 60°C temperature rise. Higher output power is possible with extra added heat sink or air circulation to reduce thermal resistance.

### Marking Information



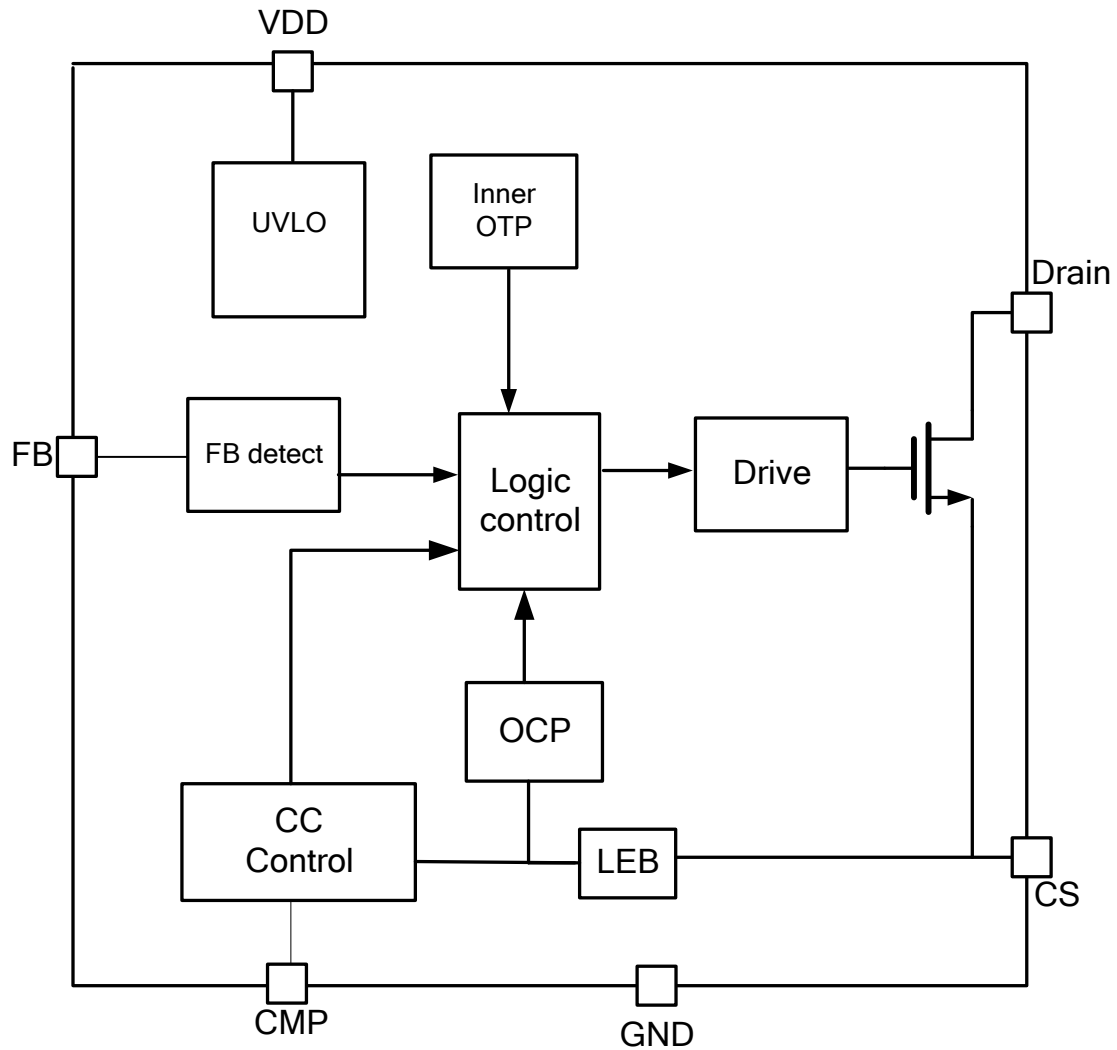
### TERMINAL ASSIGNMENTS

#### TERMINAL ASSIGNMENTS For DIP8/SOP8 Package

Pin Num	Pin Name	I/O	Description
1	VDD	P	Power supply Input.
2	FB	I	The voltage feedback terminal.
3	GND	P	Power Ground
4	CMP	I/O	Loop compensation pin. A capacitor is connected between CMP and GND.
5	CS	I	Current sensing terminal.
6	NC		Non Connection
7/8	DRAIN	I/O	MOSFET Drain terminal

#### TERMINAL ASSIGNMENTS For EASOP6 Package

Pin Num	Pin Name	I/O	Description
1	GND	P	Power Ground
2	VDD	P	Power supply Input.
3	FB	I	The voltage feedback terminal.
4	CMP	I/O	Loop compensation pin. A capacitor is connected between CMP and GND.
5	CS	I	Current sensing terminal.
6	DRAIN	I/O	MOSFET Drain terminal

**BLOCK DIAGRAM**


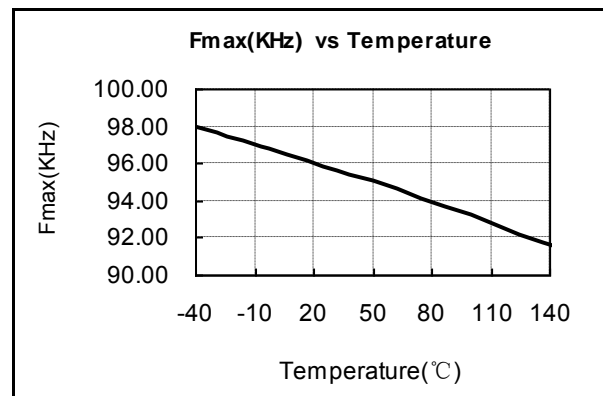
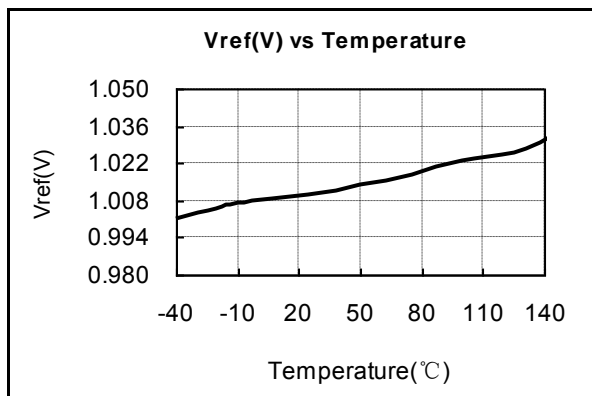
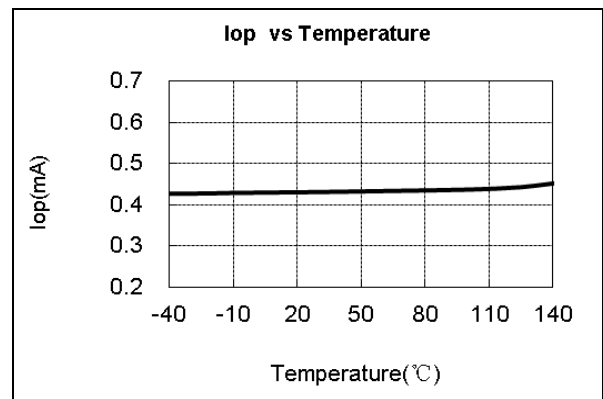
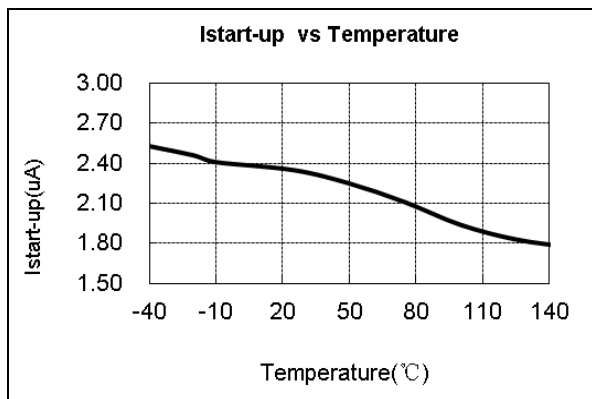
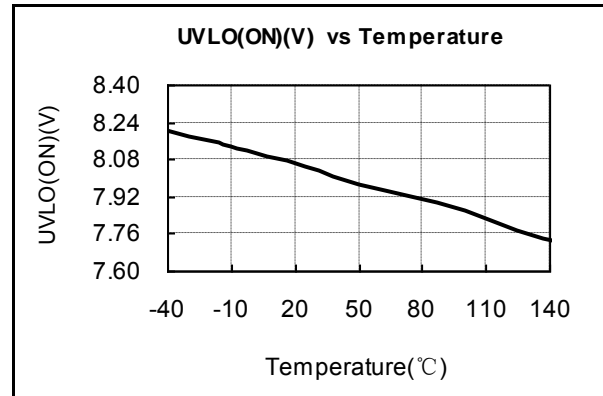
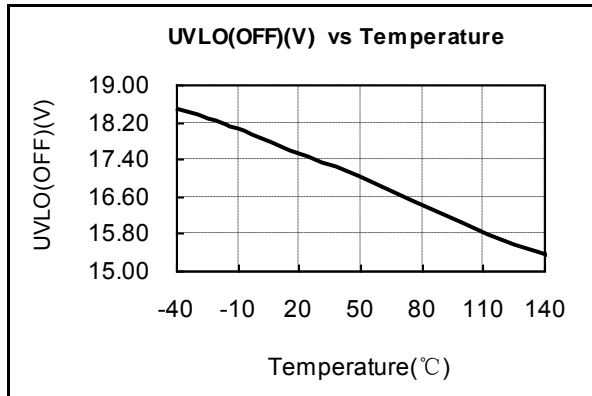
### ELECTRICAL CHARACTERISTICS

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

Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
<b>Supply Voltage (VDD) Section</b>						
I <sub>start-up</sub>	Start up current	VDD=UVLO(OFF)-1V		3	7	uA
I <sub>op</sub>	Operation current	VDD=20V, no loading		0.4	0.6	mA
UVLO(OFF)	VDD under voltage lockout exit		16	18	20	V
UVLO(ON)	VDD under voltage lockout enter		7	8	9	V
VDD_clamp	VDD clamping Voltage		28	30	32	V
<b>Current Sense Input Section</b>						
TLEB	LEB time			0.4		us
V <sub>th_otp</sub>	Over Current Threshold			0.5		V
<b>FB Input Section</b>						
V <sub>out_otp</sub>	Output Over Voltage Protection		1.42	1.5	1.58	V
V <sub>out_scp</sub>	Output Short Circuit Protection			0.25		V
I <sub>FB</sub>	Maximum Sink current from FB				2	mA
<b>QR Section</b>						
F <sub>max</sub>	Maximum Clamping Frequency			100		KHz
T <sub>off_max</sub>	Maximum Off Time			100		us
T <sub>off_min</sub>	Minimum Off Time	CS>0.15V		2		us
		CS<=0.15V		0.5		us
T <sub>on_max</sub>	Maximum On Time			25		us
<b>Error Amplifier Section</b>						
V <sub>ref</sub>	Error Amplifier Reference Voltage		0.196	0.200	0.204	V
G <sub>m</sub>	Error Amplifier Transconductance			40		uS
V <sub>clamp_cmp</sub>	CMP Pin Down_clamp Voltage			1.0		V
<b>OTP Section</b>						
T <sub>TF</sub>	Thermal regulation threshold			145		°C
OTP	Over Temperature Protection			170		°C

Product	Parameter	BV <sub>dss</sub> (V)		
		MOSFET Drain-Source Breakdown Voltage		
		Min	Typ.	Max
OB3655TAP-H		650		
OB3655TAP		630		
OB3655PCQP-H		650		
OB3655PCP-H		650		
OB3655NCP-H		650		

## CHARACTERIZATION PLOTS



## OPERATION DESCRIPTION

OB3655x is a primary-side-control fly-back PWM controller specialized for LED lighting application. It operates in primary side sensing and regulation without auxiliary winding. OB3655x 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 OB3655x to meet the start-up time requirement (<0.5s). Low start-up current is designed in OB3655x so that VDD could be charged up above UVLO threshold with small charging current. At the startup, the capacitor at CMP pin is pulled up quickly. OB3655x operates at open loop and over-current protection is set cycle-by-cycle until it senses the output voltage by FB pin up to about 0.6V. After that OB3655x operates in close loop and the transconductance of error amplifier is set to 40uS (typical).

### 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 (V<sub>cmp</sub>), which determines the turn-on time in voltage mode control. The LED output current can be approximated as:

$$I_{LED} = \eta \cdot \frac{N}{2} \cdot \frac{V_{ref}}{R_{CS}}$$

$\eta$  — The transformer coupling coefficient.

N — Turn ratio of primary side winding to secondary side winding.

R<sub>cs</sub> — The sensing resistor connected between the CS pin and GND.

V<sub>ref</sub> — Internal reference voltage.

### Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting (OCP) is offered in OB3655x. 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 power MOSFET on state.

### Quasi-Resonant Operation

OB3655x performs quasi-resonant detection through FB pin by monitoring the voltage activity on the primary 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.

### Thermal Fold-back Protection

OB3655x provides thermal foldback function to control LED output current. When temperature is up to 145°C (typical) and the output current of system will be adjusted according to the sensed temperature. The output current will be reduce to about half of the setting value at 165°C (typical). Over temperature protection is offered in OB3655x. When temperature rises above 170°C (typical), the device will stop working.

### 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 0.25V (typical), and lasts for 20mS, the GATE pin is internally pulled low to maintain the off state.

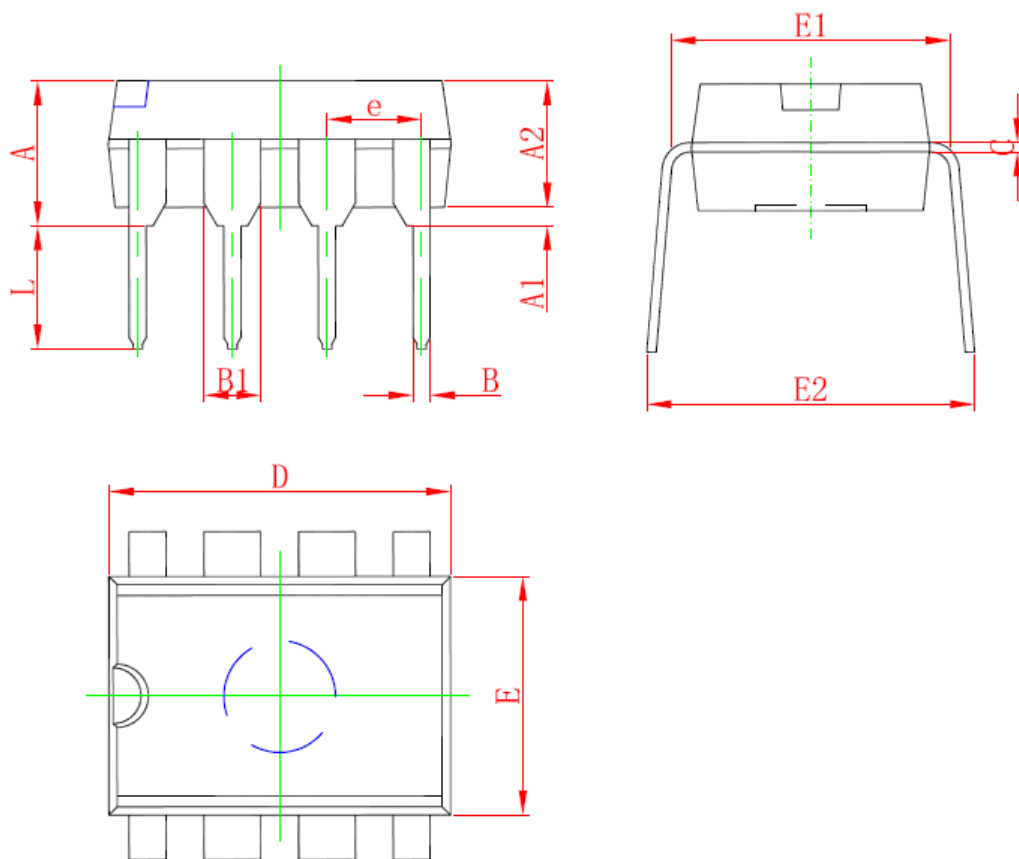
### LED Open Circuit Protection

When the LED string open circuit happens, the FB pin voltage is high. If the voltage at FB pin is higher than a threshold of approximately 1.5V (typical), the IC will shut down and enter power on startup sequence thereafter.



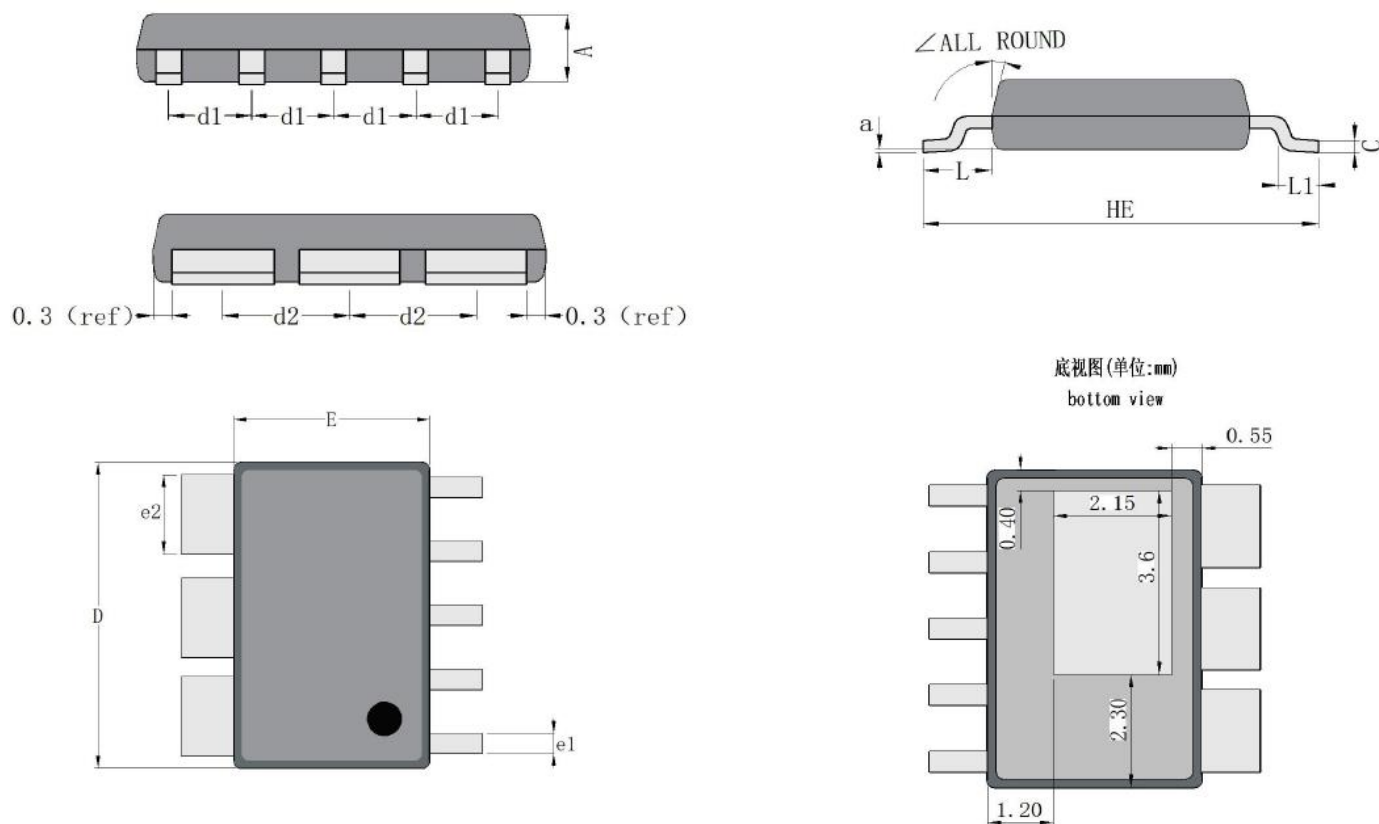
## PACKAGE MECHANICAL DATA

### DIP8



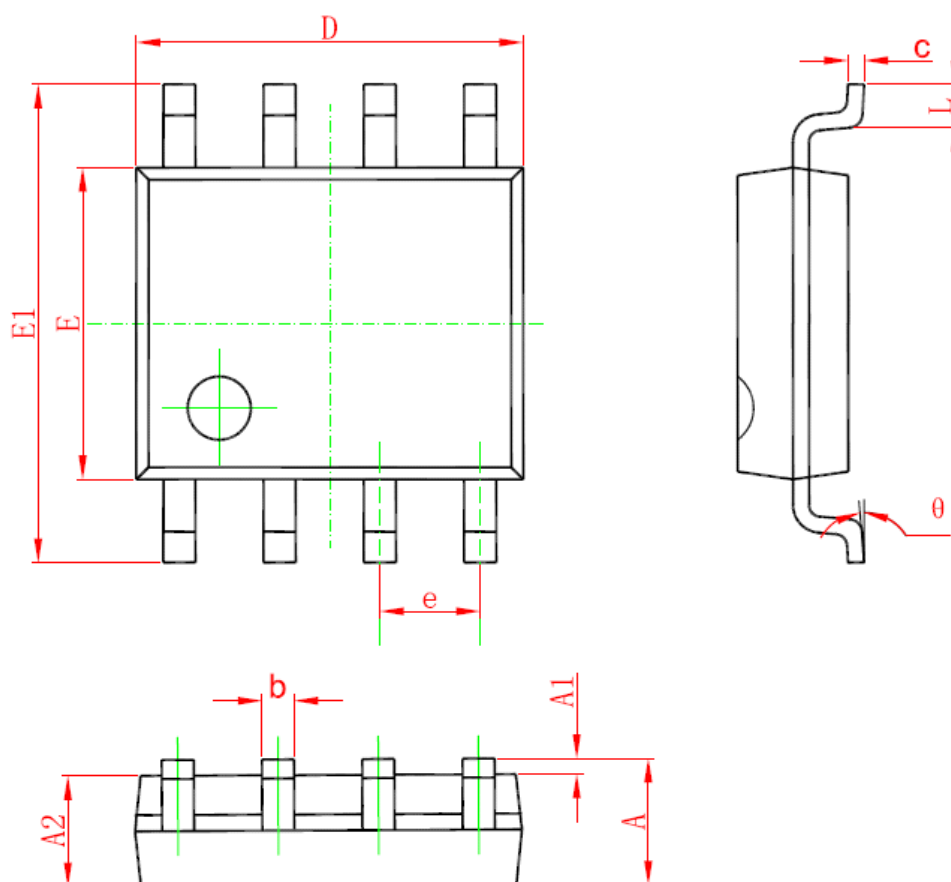
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	5.334	0.146	0.210
A1	0.381		0.015	
A2	2.921	4.953	0.115	0.195
B	0.350	0.650	0.014	0.026
B1	1.524 (BSC)		0.06 (BSC)	
C	0.200	0.360	0.008	0.014
D	9.000	10.160	0.354	0.400
E	6.096	7.112	0.240	0.280
E1	7.320	8.255	0.288	0.325
e	2.540 (BSC)		0.1 (BSC)	
L	2.921	3.810	0.115	0.150
E2	7.620	10.920	0.300	0.430

## EASOP6



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.05	1.25	0.041	0.049
C	0.15	0.22	0.006	0.009
D	6.00	6.40	0.236	0.252
E	3.70	4.10	0.146	0.161
HE	5.90	6.10	0.232	0.240
d1	1.25	1.35	0.049	0.053
d2	1.95	2.05	0.077	0.081
e1	0.35	0.45	0.014	0.018
e2	1.55	1.65	0.061	0.065
L	0.95	1.15	0.037	0.045
L1	0.40	0.80	0.016	0.031
a	0.20 (REF)		0.008 (REF)	

## SOP8



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	3.700	4.100	0.146	0.161
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
$\theta$	0°	8°	0°	8°

## IMPORTANT NOTICE

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