OB3635Ex
High PF, Low THD Offline LED Lighting Power Switch

GENERAL DESCRIPTION

OB3635Ex is an 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. It significantly simplifies the LED lighting system design by eliminating auxiliary winding.

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 and load compensation are built in OB3635Ex for high precisely constant output current control.

OB3635Ex 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.

OB3635Ex is offered in SOP8, DIP8 and TO252-5 package.

FEATURES

- High PF (>0.95)
- Low THD (<10%)
- 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
- Built-in line compensation
- Built-in load 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
- Over temperature protection (OTP)
- Thermal fold-back control
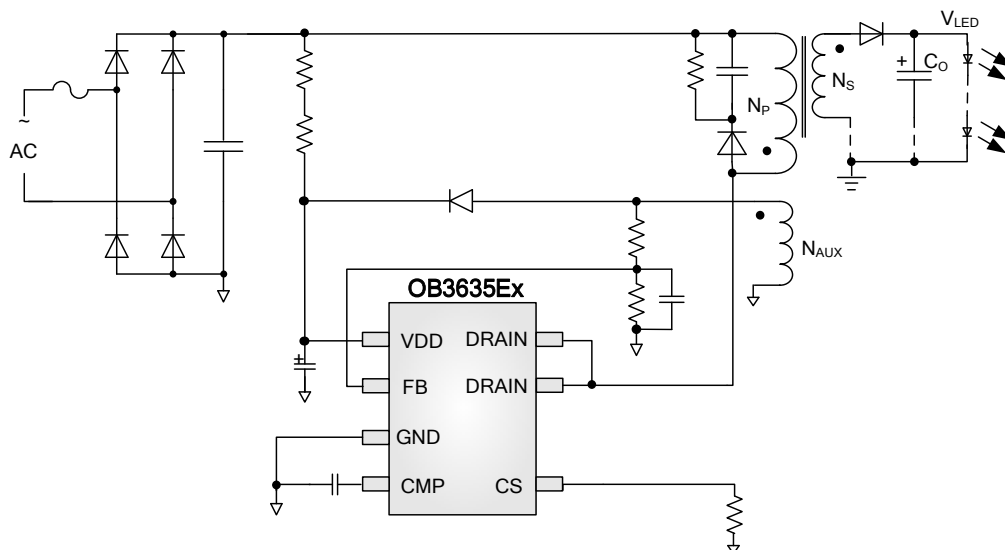
APPLICATIONS

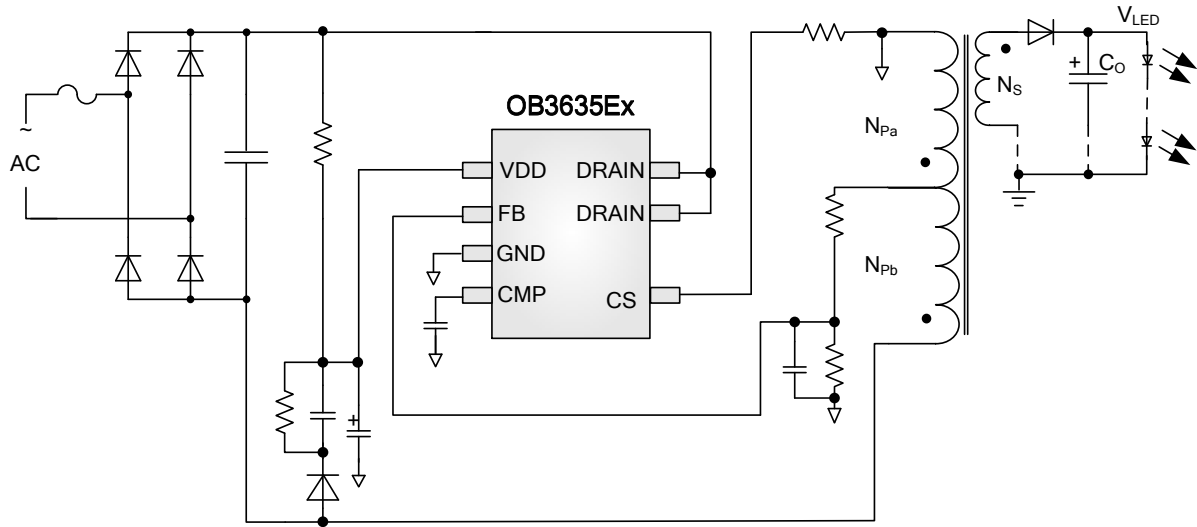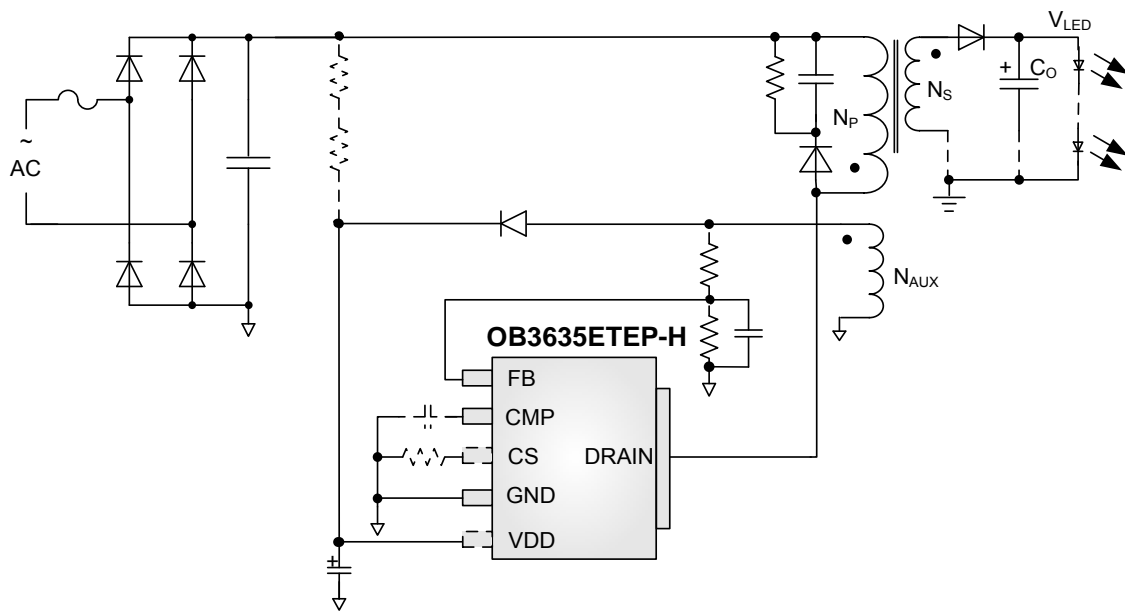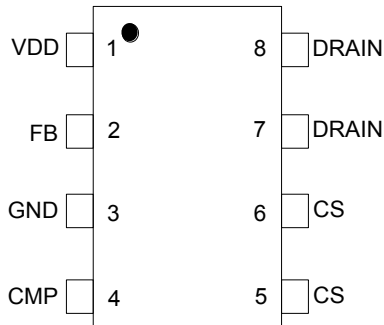- LED lighting

TYPICAL APPLICATION

Figure 1

Figure 2

Figure 3

GENERAL INFORMATION

Pin Configuration

SOP8

DIP8
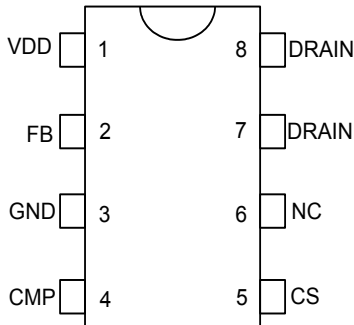
TO252-5
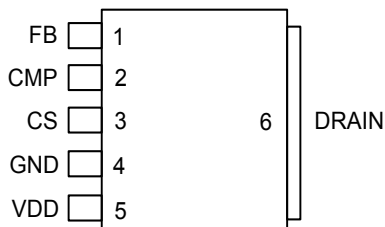
Ordering Information

Part Number	Description
OB3635ERAP	DIP8，Halogen-free in Tube
OB3635ENCP	SOP8, Halogen-free in Tube
OB3635ENCPA	SOP8, Halogen-free in T&R
OB3635ETAP-H	DIP8，Halogen-free in Tube
OB3635ERCP	SOP8, Halogen-free in Tube
OB3635ERCPA	SOP8, Halogen-free in T&R
OB3635ETCP	SOP8, Halogen-free in Tube
OB3635ETCPA	SOP8, Halogen-free in T&R
OB3635EVAP-H	DIP8, Halogen-free in Tube
OB3635ETEP-H	TO252-5, Halogen-free in Tube
OB3635ETEPA-H	TO252-5, Halogen-free in T&R

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

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
COMP Voltage	-0.3 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.
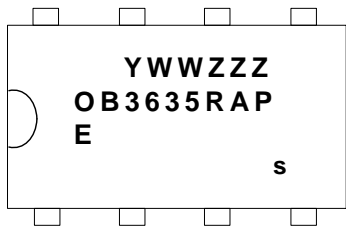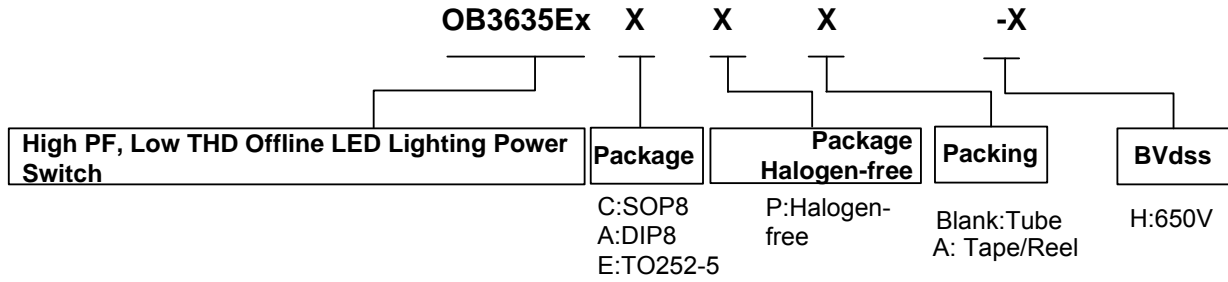
Package Dissipation Rating

Package	RθJA (℃/W)
SOP8	90℃/W
DIP8	75℃/W
TO252-5	50℃/W

Output Power Table

Product	90-264VAC	220Vac±20%
	Open Frame	Open Frame
OB3635ERAP	14W	21W
OB3635ENCP	7.5W	13.4W
OB3635ETAP-H	18W	29W
OB3635ERCP	10.4W	17.5W
OB3635ETCP	15.2W	23W
OB3635EVAP-H	24.1W	42.6W
OB3635ETEP-H	19W	33.9W

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

Marking Information

OB3635Ex   X   X   X   -X

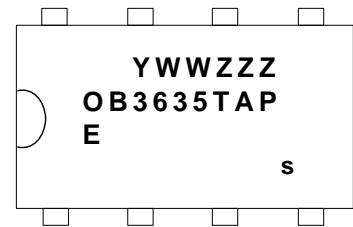| High PF, Low THD Offline LED Lighting Power Switch	Package	Package Halogen-free	Packing	BVdss
	C:SOP8 A:DIP8 E:TO252-5	P:Halogen-free	Blank:Tube A: Tape/Reel	H:650V

YWWZZZ
OB3635RAP
E
s

Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

A: DIP8

P:Halogen-free Package

E:Character Code

s: Internal Code(Optional)

YWWZZZ
OB3635NCP
E
s

Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

C: SOP8

P:Halogen-free Package

E:Character Code

S: Internal Code(Optional)

YWWZZZ
OB3635TAP
E
s

Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

A: DIP8

P:Halogen-free Package

E:Character Code

s: Internal Code(Optional)

YWWZZZ
OB3635RCP
E
s

Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

C: SOP8

P:Halogen-free Package

E:Character Code

S: Internal Code(Optional)

YWWZZZ
OB3635TCP
E
s
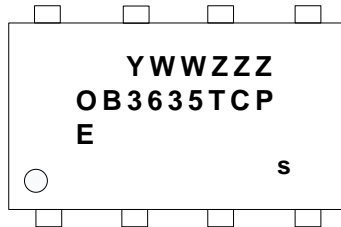
Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

C: SOP8

P:Halogen-free Package

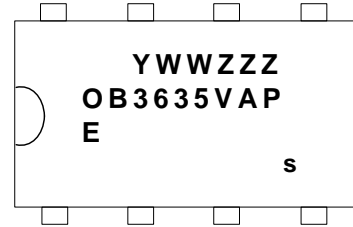E:Character Code

S: Internal Code(Optional)

YWWZZZ
OB3635VAP
E
s

Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

A: DIP8

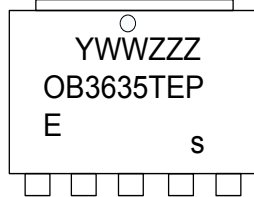P:Halogen-free Package

E:Character Code

s: Internal Code(Optional)

YWWZZZ
OB3635TEP
E
S
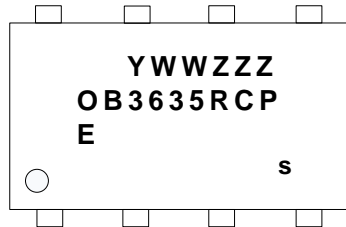
Y:Year Code

WW:Week Code(01-52)

ZZZ:Lot Code

E:TO252-5

P:Green Package(Halogen-free)

E:Character Code

s:Internal Code(Optional)

TERMINAL ASSIGNMENTS For 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 COMP and GND.
5/6	CS	I	Current sensing terminal.
7/8	DRIAN	I/O	MOSFET Drain terminal

TERMINAL ASSIGNMENTS For DIP8 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 COMP and GND.
5	CS	I	Current sensing terminal.
6	NC		Non Connection
7/8	DRIAN	I/O	MOSFET Drain terminal

TERMINAL ASSIGNMENTS For TO252-5 Package

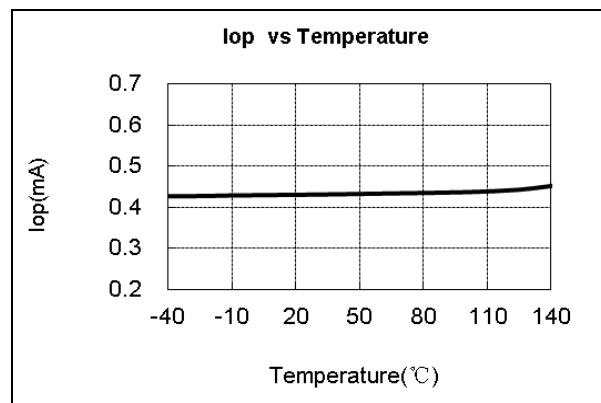| Pin Num	Pin Name	I/O	Description
1	FB	I	The voltage feedback terminal.
2	CMP	I/O	Loop compensation pin. A capacitor is connected between COMP and GND.
3	CS	I	Current sensing terminal.
4	GND	P	Power Ground
5	VDD	P	Power supply Input.
6	DRIAN	I/O	MOSFET Drain terminal

BLOCK DIAGRAM
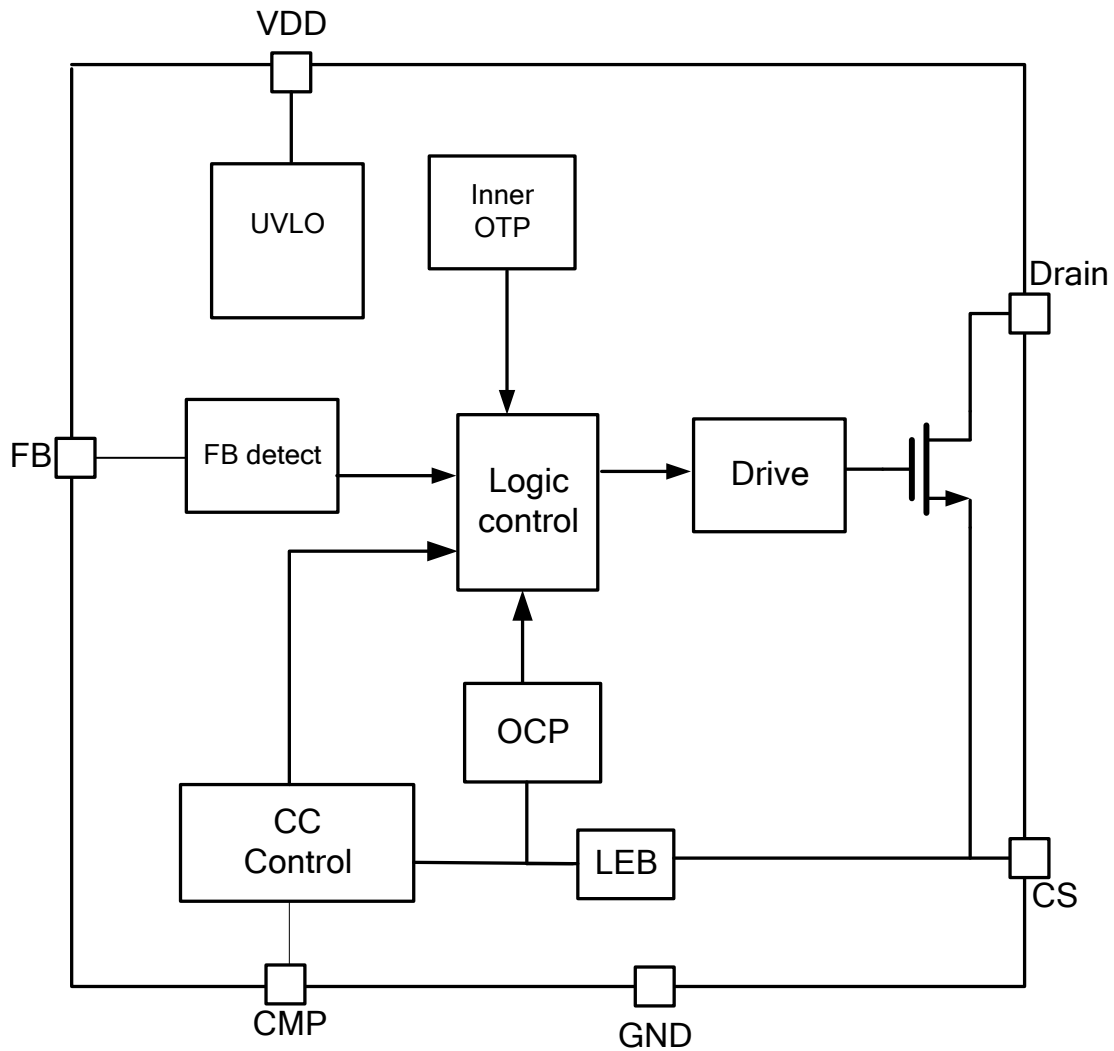
ELECTRICAL CHARACTERISTICS

(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		0.4	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
Current Sense Input Section						
TLEB	LEB time			0.4		us
Vth_ocp	Over Current Threshold	FB>0.25V	1.05	1.1	1.15	V
		FB<=0.25V		0.5		V
FB Input Section						
Vout_ovp	Output Over Voltage Protection		1.42	1.5	1.58	V
Vout_scp	Output Short Circuit Protection			0.25		V
I_FB	Maximum Sink current from FB				2	mA
QR Section						
Fmax	Maximum Clamping Frequency			100		KHz
Toff_max	Maximum Off Time			100		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
OTP Section						
T$_{TF}$	Thermal regulation threshold			145		℃
OTP	Over Temperature Protection			170		℃

Product \ Parameter	BVdss(V) MOSFET Drain-Source Breakdown Voltage		
	Min	Typ.	Max
OB3635ERAP	600		
OB3635ENCP	600		
OB3635ETAP-H	650		
OB3635ERCP	600		
OB3635ETCP	600		
OB3635EVAP-H	650		
OB3635ETEP-H	650		

CHARACTERIZATION PLOTS

UVLO(OFF)(V) vs Temperature

UVLO(ON)(V) vs Temperature

Istart-up vs Temperature

Iop vs Temperature

Vref(V) vs Temperature

Fmax(KHz) vs Temperature
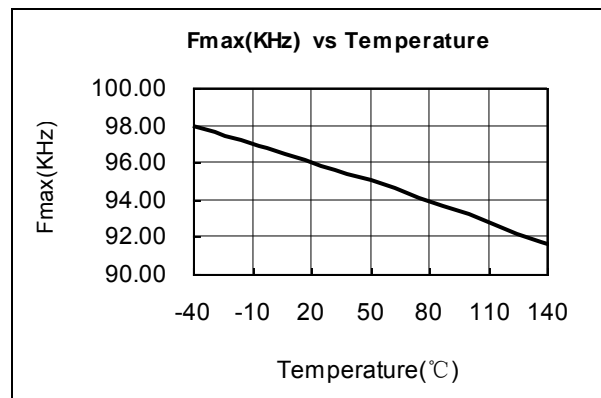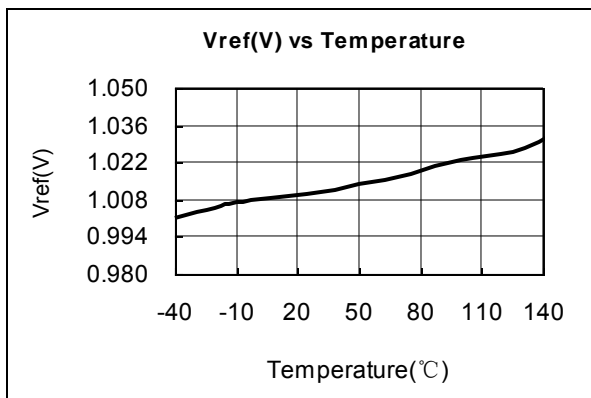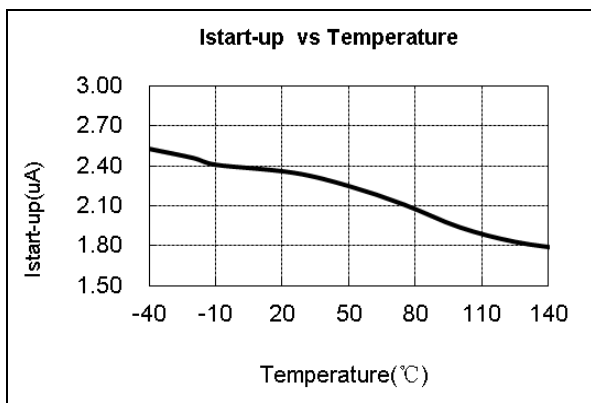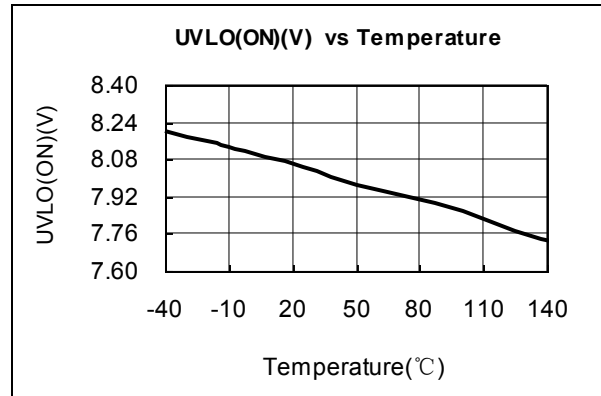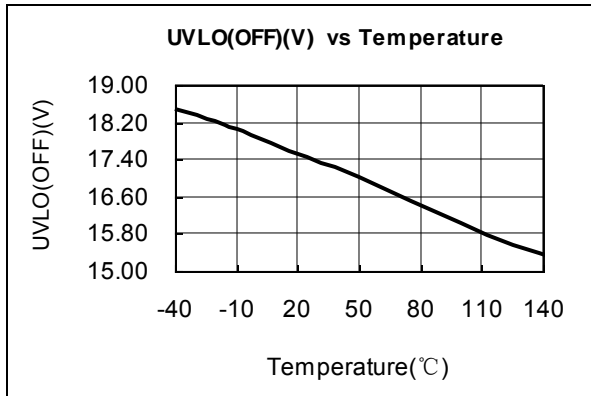
OPERATION DESCRIPTION

OB3635Ex is a 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 without auxiliary winding. OB3635Ex 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 OB3635Ex to meet the start-up time requirement (<0.5s). Low start-up current is designed in OB3635Ex 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. OB3635Ex 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 OB3635Ex 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 (Vcmp), which determines the turn-on time in voltage mode control. The LED output current can be approximated as:

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

η — The transformer coupling coefficient.
N — Turn ratio of primary side winding to secondary side winding.
Rcs — The sensing resistor connected between the CS pin and GND.
Vref — Internal reference voltage.

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).

Current Sensing and Leading Edge Blanking
Cycle-by-Cycle current limiting (OCP) is offered in OB3635Ex. 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
OB3635Ex 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.

Line/Load Compensation
OB3635Ex provides internal line compensation and load 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 and output voltage.

Thermal Fold-back Protection
OB3635Ex provides thermal foldback function to control LED output current. When temperature is up to 145℃ (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℃ (typical). Over temperature protection is offered in OB3635Ex. When temperature rises above 170℃ (typical), the device will stop working.

LED Short Circuit Protection
When LED string is short, the FB voltage is low. If the voltage at FB pin is lower than a threshold of approximately 0.25V (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 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.

Layout Suggestion

a) To achieve better EMI and reduce frequency interference, the loop of primary, secondary

and auxiliary switching circuit should be kept small .

b) The COMP capacitor C4, FB resistor R5/R6 and capacitor C6, VDD capacitor C2 and CS resistor R1/R2 should be put close to IC Pin.

c) CS resistor to IC GND trace should be kept as short as possible.

d) The power/high current GND and IC signal GND should be connect to Bulk capacitor GND separately.
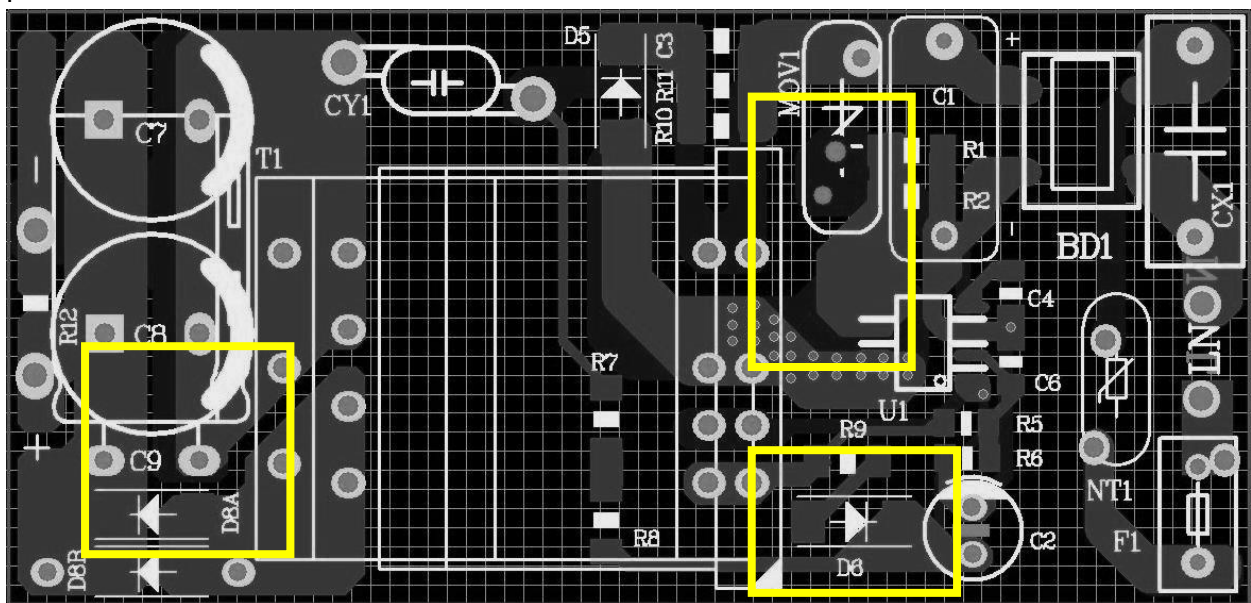
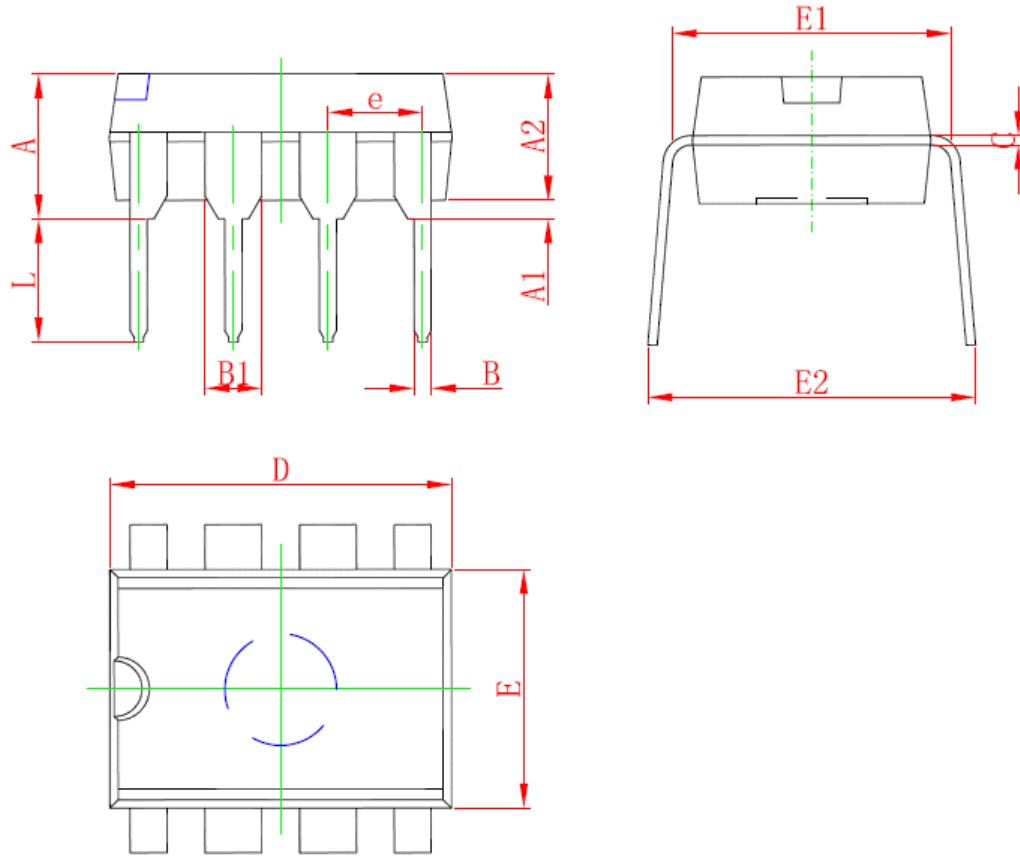

PACKAGE MECHANICAL DATA

SOP8
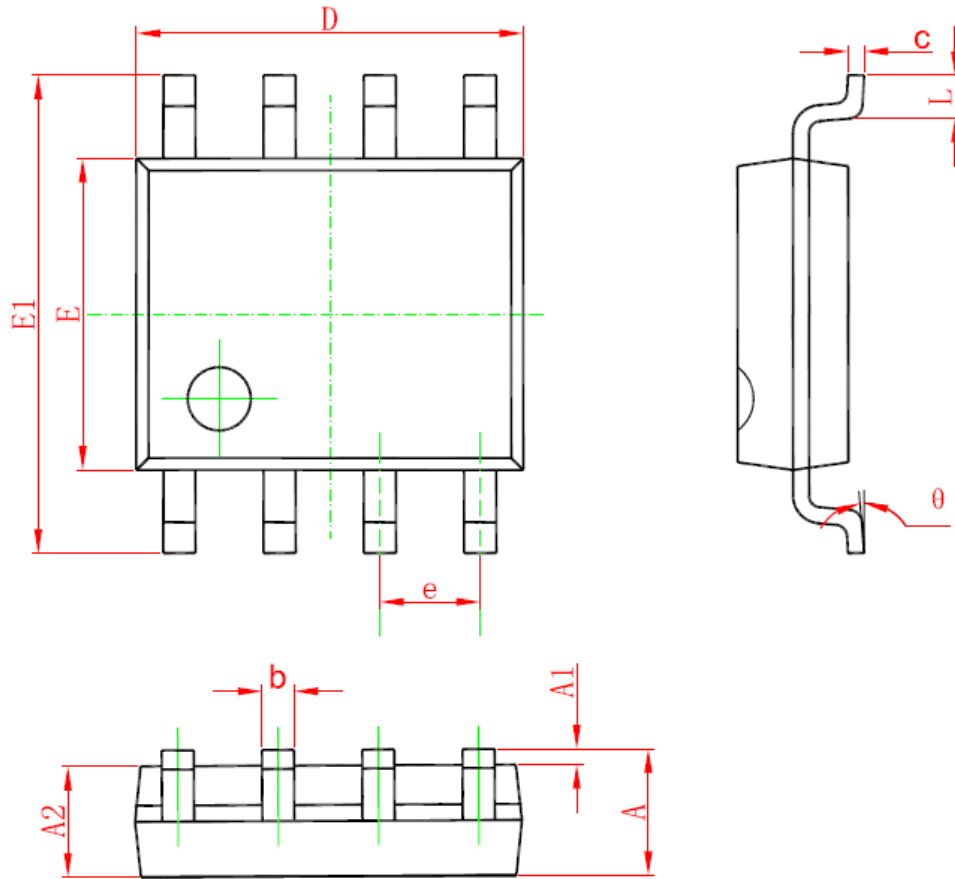
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	4.700	5.150	0.185	0.203
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0º	8º	0º	8º

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

TO252-5
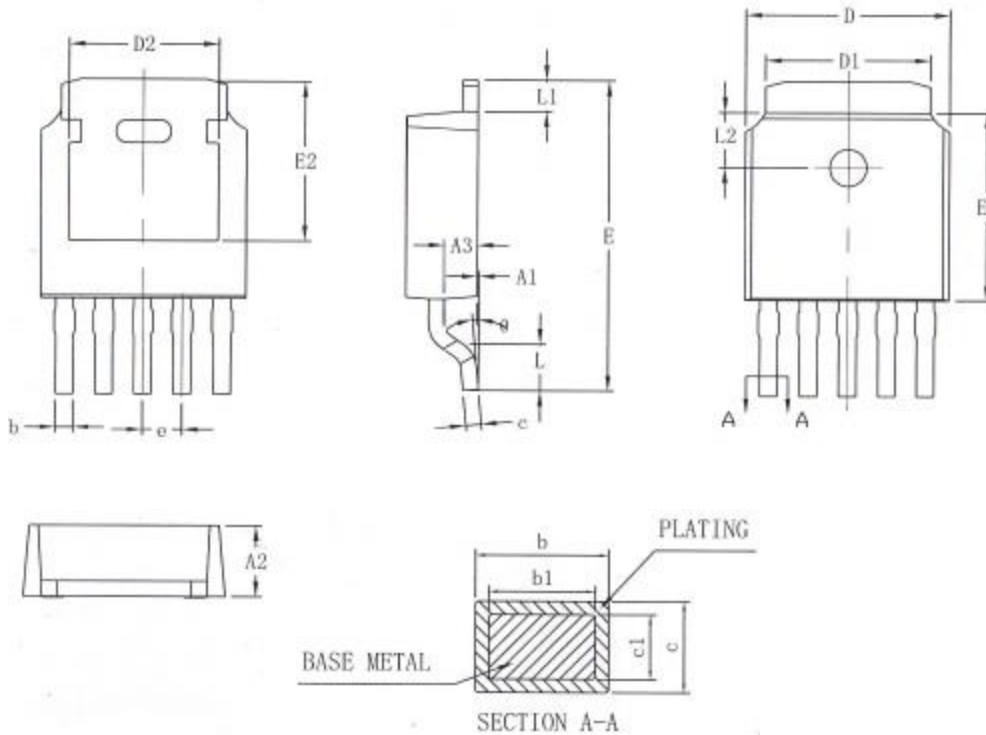
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A1	0	0.100	0	0.004
A2	2.200	2.400	0.087	0.094
A3	0.967	1.117	0.038	0.044
b	0.535	0.585	0.021	0.023
c	0.498	0.518	0.0196	0.0204
D	6.550	6.650	0.258	0.262
D1	5.334 (BSC)		0.210 (BSC)	
D2	4.826 (BSC)		0.190 (BSC)	
E	9.800	10.100	0.386	0.398
E1	6.050	6.150	0.238	0.242
E2	5.175 (BSC)		0.204 (BSC)	
e	1.270 (BSC)		0.050 (BSC)	
L	1.400	1.600	0.055	0.063
L1	1.012 (BSC)		0.040 (BSC)	
θ	0º	8º	0º	8º

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