# OB3638

**High PF, PSR LED Controller**

## GENERAL DESCRIPTION

The OB3638 is a high power factor, monolithic flyback controller with advanced features to provide high efficiency control and high accuracy constant current output for LED lighting applications.

OB3638 offers fast startup feature by charging VDD through the SW pin, a constant on-time control for power factor correction (PFC), zero current detector (ZCD) to ensure transition mode (TM) operation, an error amplifier for accurate current regulation and on-chip MOSFET for switching.

OB3638 offers comprehensive protection coverage including VDD under voltage lockout (UVLO), VDD over voltage protection, load voltage over voltage protection, cycle-by-cycle current limiting, over temperature protection, LED string open/short protection, driver output clamping for external power MOSFET protection, current sense resistor short protection, transformer saturation protection.

OB3638 is offered in SOP8 package.

## FEATURES

- Primary-Side Control with Single Stage PFC Topology
- Minimized BOM Count
- Fast startup time (<0.1S)
- Transition Mode (TM) operation to achieve high efficiency
- High current accuracy
- Selectable threshold of load compensation
- Source drive operation mode
- Cycle-by-Cycle Current Limiting (OCP)
- VDD Over Voltage Protection
- Output Over Voltage Protection
- Over-temperature Protection
- VDD Under Voltage Lockout (UVLO)
- LED string open protection
- LED string short protection
- Current sense resistor short/open protection
- Transformer saturation protection
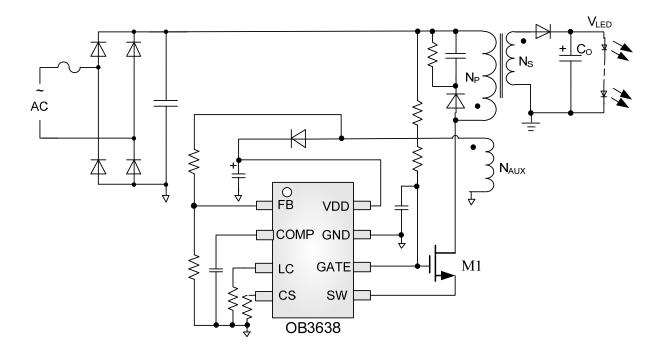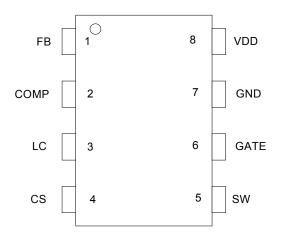
## APPLICATIONS

- LED lighting

## TYPICAL APPLICATION



*Figure1: OB3638 Typical Application Schematic*

## GENERAL INFORMATION

**Terminal Assignment**

In SOP8 Package.

| | | | |
|---|---|---|---|
| FB | 1 | 8 | VDD |
| COMP | 2 | 7 | GND |
| LC | 3 | 6 | GATE |
| CS | 4 | 5 | SW |

**Ordering Information**

| Part Number | Description |
|---|---|
| OB3638CP | 8 Pin SOP, Pb free in Tube |
| OB3638CPA | 8 Pin SOP, Pb free in Taping |

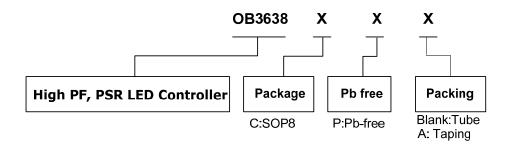**Note1:** All Devices are offered in Pb-free Package if not otherwise noted.

**Package Dissipation Rating**

| Package | RθJA (℃/W) |
|---|---|
| SOP8 | 150 |

**Absolute Maximum Ratings**

| Parameter | Value |
|---|---|
| VDD Input Voltage to GND | -0.3V to 24V |
| GATE to GND | -0.7V to 24V |
| SW to GND | -0.7V to 24V |
| FB, COMP,LC and CS to GND | -0.7V to 7V |
| Operating Ambient Temp. $T_A$ | -20℃ ~ 85℃ |
| Operating Junction Temp. $T_J$ | -40 ~150℃ |
| Min/Max Storage Temp. $T_{stg}$ | -55~150℃ |
| Lead Temp. (10 Sec) | 260 ℃ |

**Note2:** 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.

**OB3638    X    X    X**

| High PF, PSR LED Controller | Package | Pb free | Packing |
|---|---|---|---|
| | C:SOP8 | P:Pb-free | Blank:Tube A: Taping |

## Marking Information

YWWZZZ
OB3638CP

**s**

Y: Year Code

WW: Week Code (01-52)

ZZZ:Lot Code

C: SOP8

P:Pb-free Package

S: Internal Code(Optional)

## Terminal Assignment

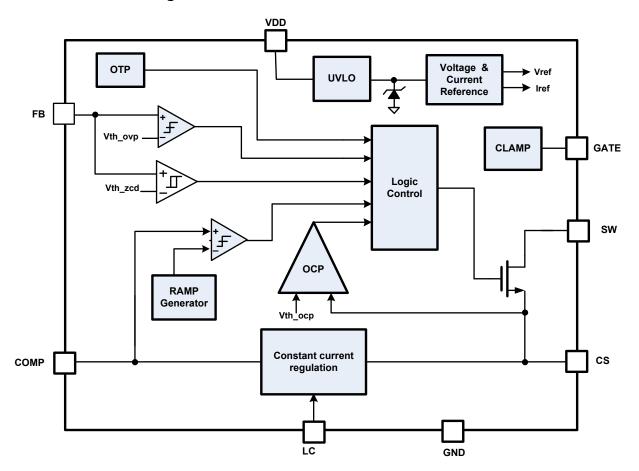| Number | Pin Name | I/O | Pin Function |
|---|---|---|---|
| 1 | FB | I/O | Feedback pin. When activated, a new switching cycle starts. Connect this pin through a resistor divider from the auxiliary winding to ground. This pin is also used for output over voltage protection (OVP). |
| 2 | COMP | I/O | Loop compensation pin. Connect to a compensation network to stabilize the LED driver and achieve a constant LED driver current. |
| 3 | LC | I/O | Load compensation pin. This pin sets the range of load compensation. This pin can be float, ground and connected a resistor to GND to set three different compensation range. |
| 4 | CS | I/O | Current sense input pin. |
| 5 | SW | I/O | Drain of internal MOSFET. |
| 6 | GATE | I/O | The gate voltage clamp of external power MOSFET. |
| 7 | GND | P | Ground. |
| 8 | VDD | P | Power supply voltage pin. |

## Functional Block Diagram



*Figure2: OB3638 Functional Block Diagram*

## Electrical Characteristics

VDD=16V, $T_A$=25℃, if not otherwise noted.

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Supply Voltage Section** | | | | | | |
| I_VDD_ST | Standby Current | VDD=14V | | 450 | 500 | uA |
| I_static | Static Current | VDD=16V, no switching | | 1.2 | 1.5 | mA |
| UVLO(ON) | Under Voltage Lockout Enter | VDD falling | 5.5 | 6.0 | 6.5 | V |
| UVLO(OFF) | Under Voltage Lockout Exit | VDD rising | 9 | 9.5 | 10 | V |
| VDD_HOLD | VDD Hold Voltage | VDD failing | 7 | 7.5 | 8 | V |
| VDD_OVP | VDD Over Voltage Protection | | 19.5 | 21 | 22.5 | V |
| **Current Sense Section** | | | | | | |
| TLEB | LEB time | | | 300 | | ns |
| Vth_oc | Over Current Threshold | | 0.95 | 1.00 | 1.05 | V |
| Vth_oc_short | Over Current Threshold when VFB < 0.5V | | 0.45 | 0.50 | 0.55 | V |
| Td_oc | OCP Propagation Delay | | | 40 | | ns |
| **FB Section** | | | | | | |
| Vovp | Output over voltage protection | | 3.395 | 3.500 | 3.605 | V |
| Tfb_leb | FB leading edge blanking time | | 1.5 | 2.0 | 2.5 | us |
| **Gm amplifier section** | | | | | | |
| Vref | EA Reference Voltage | | 0.196 | 0.200 | 0.204 | V |
| Gm | EA Transconductance Gain | | | 100 | | us |
| **PWM Control Section** | | | | | | |
| Toff_max | Re-start timer period | | | 75 | | us |
| Ton_max | Maximum on time | | | 25 | | us |
| Fmax | Maximum operation frequency | | | 100 | | kHz |
| **Temperature Section** | | | | | | |
| OTP | OTP trigger threshold | | | 150 | | ℃ |
| **Gate Section** | | | | | | |
| Vclamp_startup | Gate clamp voltage at startup | | | 20 | | V |
| Vclamp_op | Gate clamp voltage at operation | | | 13.5 | | V |
| Iclamp | Gate clamp current at operation | | | 10 | | mA |
| **SW Section** | | | | | | |
| Rds_on | On-chip MOSFET on resistor | | | 0.4 | | Ω |

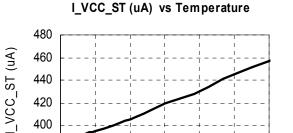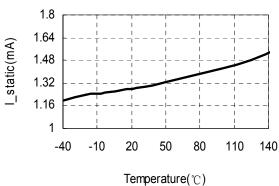## TYPICAL PERFOMANCE CHART
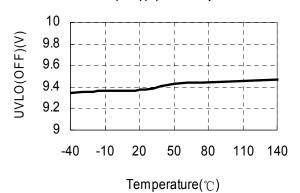
### I_VCC_ST (uA) vs Temperature
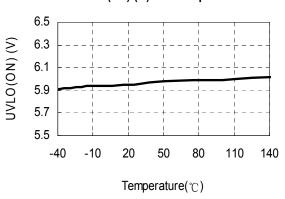


### I_static(mA) vs Temperature



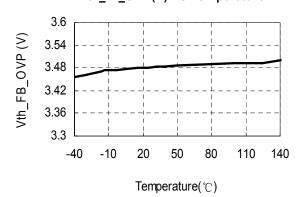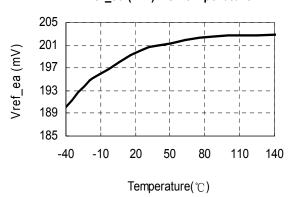### UVLO(OFF)(V) vs Temperature



### UVLO(ON) (V) vs Temperature



### Vth_FB_OVP (V) vs Temperature



### Vref_ea (mV) vs Temperature

# Function Description

## General Operation

The OB3638 is a primary-side-control and high power factor flyback PWM controller specialized for LED lighting application. It operates in primary side sensing and regulation, thus opto-coupler and TL431 are not required. The transition mode control greatly reduces the switch turn-on loss, improves the conversion efficiency. It provides very good power factor.

The principle of operation can be understood by referring to the block diagram.

## Startup

When system starts up, the GATE pin is charged by the line voltage through a resistor and finally clamped at 20V (typical), the external MOSFET turns on. And the VDD pin is directly charged by line voltage through MOSFET and from SW to internal charge control circuit, this makes the startup very fast(normally within 0.1S) than conventional startup structure. When the VDD voltage exceeds UVLO_OFF threshold voltage (typical 9.5V), the IC starts to switch and the internal charge control circuit stop charging to VDD, and the VDD is supplied by the AUX winds instead of line voltage. At normal operation, when AUX winds positive voltage not enough to charge VDD, causing VDD to drop. Instead, if the VDD drops below the VDD_HOLD threshold voltage (typical 7.5V), the internal charging circuit triggers and charges VDD holding at 7.5V. Therefore, output voltage can operate in widely range by this function.

## UVLO

An under-voltage lockout with a hysteresis control is provided on VDD. When the voltage at this pin exceeds a threshold of approximately 9.5V, the IC starts the normal operation. If the voltage at this pin drops below a threshold of approximately 6V, the IC stops switching operation. The IC resumes switching operation when the voltage at pin VDD recovers to a voltage above 9.5V (typical).

## LED Constant Current Regulation

OB3638 uses the primary side constant current control method to accurately control the LED current. The LED mean current can be approximated as:

$$I_{LED}[mA] = \eta * \frac{N}{2} * \frac{200[mV]}{R_{CS}[\Omega]}$$

$\eta$ — The transformer coupling coefficient.

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

Rcs—the sensing resistor connected between CS pin and GND.

## Current Sensing

OB3638 performs zero current detection (ZCD) through FB pin by monitoring the voltage activity on the auxiliary windings in series with external resistors. This voltage features output voltage. When the stored energy of the fayback transformer fully release to the output, the voltage at FB pin decreases. When FB pin voltage falls below 0.3V (typical), an internal ZCD comparator is triggered and a new PWM switching cycle is initiated.

## Load Compensation Setting

The OB3638 offers load compensation range setting function by configuration the LC pin to be compatible with different system. The following table shows the setup and the related load compensation percent of the full current range.

| LC pin | Compensation Range |
|---|---|
| Floating | 3.33% |
| GND | 5.56% |
| 100K~200K ohm resistor | 8.33% |

## Maximum and Minimum On-Time

The minimum on-time of the system is determined by the LEB time (typical 300ns). The IC limits the on-time to a maximum value of approximately 25us (typical).

## Output OVP Protection

The output over-voltage condition is monitored independently through the voltage at FB pin. During normal operation, when the voltage at FB pin exceeds a threshold of approximately 3.5V (typical), the over-voltage protection function is activated and the driver is turned off immediately.

## VDD OVP Protection

VDD is supplied with auxiliary winding output. When VDD is higher than 21V (typical), OVP protection is triggered and driver is shut down, so the device enters power on startup sequence thereafter.

## LED String Open Protection

When LED string open happens, the positive plateau of FB voltage rise up due to the auxiliary winding voltage increases. If the voltage at FB pin is higher than a threshold of approximately 3.5V (typical), the over-voltage protection function is activated and the driver is turned off immediately.

## LED String Short Protection

When LED string is short, the positive plateau of FB voltage from auxiliary winding falls to near zero. If the voltage at FB pin is lower than a threshold of approximately 0.45V (typical), the threshold of OCP will drop down from 1V (typical) to 0.5V

(typical), COMP pin voltage will increase. When COMP voltage reach 4.2V, the switching is stopped immediately.
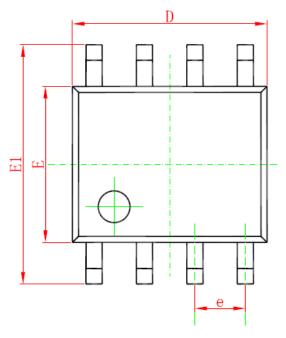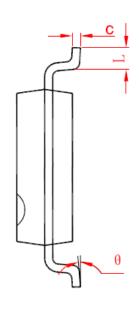
**Thermal Shutdown**

OB3638 provides an on chip thermal shutdown protection. The IC will stop switching when the junction temperature exceeds the thermal shutdown temperature, typically 150 ℃

## PACKAGE MECHANICAL DATA
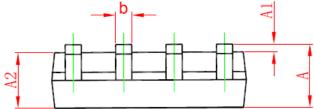
### SOP8 PACKAGE OUTLINE DIMENSIONS



| 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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