**GENERAL DESCRIPTION**

The OB3330 is a power factor correction, primary-side-control LED lighting driver with advanced features to provide high efficiency control for lighting applications.

OB3330 features an internal start-up timer for stand-alone applications, an analog multiplier for power factor correction (PFC), zero current detectors (ZCD) to ensure transition mode (TM) operation, a current sensing comparator with built-in leading-edge blanking, and a totem pole output.

OB3330 offers great protection coverage including VCC under voltage lockout (UVLO), VCC over voltage protection, load voltage over voltage protection, Level selectable cycle-by-cycle current limiting, over temperature protection, LED open/short circuit protection and gate drive output clamping for external power MOSFET protection.

**FEATURES**

- Primary-Side Control with Single Stage PFC Topology
- Minimized BOM Count
- Transition Mode (TM) Operation to Achieve High Efficiency
- Analog multiplier for Power Factor Correction
- High Current Accuracy
- Cycle-by-Cycle Current Limiting (OCP)
- Selectable Threshold of OCP
- VCC Over Voltage Protection
- Output Over Voltage Protection
- Over-temperature Protection
- LED Open Circuit Protection
- LED Short Circuit Protection
- Soft-start
- VCC Under Voltage Lockout (UVLO)
- Ultra-low Start-up Current

**APPLICATIONS**

- LED Lighting
- Industrial and Commercial lighting
- Residential lighting

**TYPICAL APPLICATION**

![OB3330 Typical Application Schematic](image)

*Figure 1: OB3330 Typical Application Schematic*
OB3330
High Performance LED Lighting Driver

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC Input Voltage to GND</td>
<td>-0.3V to 40V</td>
</tr>
<tr>
<td>GATE to GND</td>
<td>-0.3V to 40V</td>
</tr>
<tr>
<td>I/O (except GATE) to GND</td>
<td>-0.3V to 7V</td>
</tr>
<tr>
<td>Operating Ambient Temp. $T_A$</td>
<td>-20°C ~ 85°C</td>
</tr>
<tr>
<td>Operating Junction Temp. $T_J$</td>
<td>-40 ~ 150°C</td>
</tr>
<tr>
<td>Min/Max Storage Temp. $T_{DS}$</td>
<td>-55 ~ 150°C</td>
</tr>
<tr>
<td>Lead Temp. (10 Sec)</td>
<td>260 °C</td>
</tr>
</tbody>
</table>

Recommended Operating Range

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC Voltage</td>
<td>11V to 25V</td>
</tr>
</tbody>
</table>

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OB3330CP</td>
<td>8 Pin SOP, Pb free in Tube</td>
</tr>
<tr>
<td>OB3330CPA</td>
<td>8 Pin SOP, Pb free in T&amp;R</td>
</tr>
</tbody>
</table>

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

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

YWWZZZ
OB3330CP
s

Y: Year Code
WW: Week Code (01-52)
ZZ: Lot Code
C: SOP8
P: Pb-free Package
S: Internal Code (Optional)
### Pin Configuration for OB3330

![Pin Configuration Diagram](image)

### Terminal Assignment for OB3330

<table>
<thead>
<tr>
<th>Number</th>
<th>Pin Name</th>
<th>I/O</th>
<th>Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ZCD</td>
<td>I</td>
<td>Zero current detection 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).</td>
</tr>
<tr>
<td>2</td>
<td>OCP_TH</td>
<td>I/O</td>
<td>OCP threshold level selecting pin. Connected an external resistor to ground to select the OCP threshold voltage.</td>
</tr>
<tr>
<td>3</td>
<td>MULT</td>
<td>I</td>
<td>Input of multiplier pin. Connected this pin to line voltage after bridge diodes via a resistor divider to provide sinusoidal reference voltage to the current loop.</td>
</tr>
<tr>
<td>4</td>
<td>COMP</td>
<td>I/O</td>
<td>Loop compensation pin. Connect a compensation network to stabilize the LED driver and achieve a constant LED driver current.</td>
</tr>
<tr>
<td>5</td>
<td>VCC</td>
<td>P</td>
<td>DC supply voltage pin.</td>
</tr>
<tr>
<td>6</td>
<td>GATE</td>
<td>O</td>
<td>Gate drive output pin.</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>P</td>
<td>Ground pin.</td>
</tr>
<tr>
<td>8</td>
<td>CS</td>
<td>I</td>
<td>Current sense input pin.</td>
</tr>
</tbody>
</table>
Figure 2: OB3330 Functional Block Diagram
## Electrical Characteristics

$V_{CC}=16\text{V}$, $T_A=25^\circ\text{C}$, if not otherwise noted.

### Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit
--- | --- | --- | --- | --- | --- | ---
$V_{CC\_ST}$ | Standby Current | $V_{CC}=14\text{V}$ | 5 | 15 | | \(\mu\text{A}\)
$l_{static}$ | Static Current | $V_{CC}=16\text{V}$, no switching | 1.5 | 2 | | mA
$UVLO\text{(ON)}$ | VCC Under Voltage Lockout Enter | VCC falling | 8 | 9 | 10 | V
$UVLO\text{(OFF)}$ | VCC Under Voltage Lockout Exit | VCC rising | 13.6 | 14.6 | 15.6 | V
$V_{CC\_clamp}$ | VCC Clamp Protection | | 32 | | | V
$V_{CC\_OVP}$ | VCC Over Voltage Protection | | 30 | | | V

### Current Sense Section

- $T_{\text{leb}}$: Lead Edge Blanking Time
  - 300 ns
- $T_{\text{oc}}$: OCP Propagation Delay
  - From OCP comparator to Gate drive
  - 100 ns
- $l_{\text{OC}}$: Source current of OCP_TH PIN
  - $V_{CC}=16\text{V}$
  - 17 | 28 | 39 | \(\mu\text{A}\)
- $V_{\text{th\_OCP}}$: Threshold voltage of over current protection
  - $0\text{V}<V_{OC\_TH}<0.3\text{V}$
  - 2.1 V
  - $0.3\text{V}<V_{OC\_TH}<1.5\text{V}$
  - 1.8 V
  - $V_{OC\_TH}>1.5\text{V}$
  - 1.5 V

### Multiplier Section

- $V_{\text{mult}}$: Linear Operating Range
  - $\text{COMP}=3\text{V}$
  - 0 to 3 V
- $\Delta V_{\text{cs}}/\Delta V_{\text{mult}}$: Output Max. Slope
  - $\text{MULT}=\text{from 0 to 0.5V}$,
  - $\text{COMP}=4\text{V}$
  - 2.8 V/V
- $K$: Gain
  - $\text{MULT}=1\text{V}$, $\text{COMP}=2.2\text{V}$
  - 0.6 | 0.75 | 0.9 | 1/V

### ZCD Section

- $V_{\text{OVP}}$: Output Over Voltage Protection
  - 1us delay after turn off
  - 3.8 | 4 | 4.2 | V
- $V_{\text{ZCD\_LOW}}$: ZCD Low Voltage Detection
  - 0.9 V
- $V_{\text{dem\_H}}$: When ZCD rise up this voltage, demagnetization began
  - 0.9 V
- $V_{\text{dem\_L}}$: When ZCD drop below this voltage, demagnetization finished
  - 0.3 V

### Gm Amplifier Section

- $V_{\text{ref}}$: EA Reference Voltage
  - 394 | 400 | 406 | mV
- $G_{\text{m}}$: EA Transconductance Gain
  - 80 | | | uS
- $G_{\text{in}}$: DC gain
  - 60 | 70 | | dB
- $V_{\text{out}}$: Dynamic range
  - 1.2 to 4.5 V
- $V_{\text{comp\_h}}$: Upper clamp voltage
  - 6 V
- $V_{\text{comp\_l}}$: Lower clamp voltage
  - 1.2 V
- $I_{\text{source\_max}}$: EA Maximum Source Current
  - 100 | | | uA
- $I_{\text{sink\_max}}$: EA Maximum Sink Current
  - 32 | | | uA

### Watch Dog Section

- $T_{\text{off\_max}}$: Re-start timer period
  - 55 | us
- $T_{\text{off\_min}}$: Minimum off time
  - 3.5 | us
- $T_{\text{on\_max}}$: Maximum on time
  - 50 | us

### OTP Section

- $T_{\text{OTP\_on}}$: Over Temperature Protection
  - 120 | 140 | 160 | \(^\circ\text{C}\)

### Gate Drive Output Section

- $V_{\text{OL}}$: Output Low Level
  - $V_{CC}=16\text{V}$ at $I_{\text{out}}=100\text{mA}$
  - 1.5 V
- $V_{\text{OH}}$: Output High Level
  - $V_{CC}=16\text{V}$ at $I_{\text{out}}=100\text{mA}$
  - 8 V
- $V_{\text{clamp}}$: Output Clamping Voltage
  - $V_{CC}=28\text{V}$
  - 11 | 12.5 | | V
- $T_{r}$: Rising Edge Time
  - $\text{CL}=1\text{nf}$, 10~90%
  - 80 | 150 | nS
- $T_{f}$: Falling Edge Time
  - $\text{CL}=1\text{nf}$, 10~90%
  - 30 | 70 | nS
OB3330
High Performance LED Lighting Driver

Function Description

General Operation
The OB3330 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
The typical startup current of OB3330 is 5uA when VCC pin is lower than the UVLO off threshold. VCC is charged through the start up resistor from the AC line. A high value, low wattage startup resistor can be used to minimize the power loss.

UVLO
An under-voltage lockout protection features with a hysteresis of about 5.6V is provided for VCC. When the voltage at this pin exceeds a threshold of approximately 14.6V, the IC starts the normal operation. If the voltage at this pin drops below a threshold of approximately 9V, the IC stops switching operation. The IC resumes switching operation when the voltage at pin VCC recovers to a voltage above 14.6V.

LED Constant Current Regulation
OB3330 use the primary side constant current control method to accurately control the LED current. The LED mean current can be approximated as:

\[ I_{LED} = \frac{N \cdot 400 [mV]}{2 \cdot R_{cs} [\Omega]} \]

N—Turn ratio of primary side winding to secondary side winding.
Rcs—the sensing resistor connected between the MOSFET source and GND.

Current Sensing

Cycle-by-Cycle current limiting (OCP) is offered in OB3330. The switch current is detected by a sense resistor connecting the CS pin to GND. An internal leading edge blanking circuit chops off the sense voltage spike at initial pin in state due to Snubber diode reverse recovery so that the external RC filtering is no longer required. The current limit comparator is disabled and thus cannot turn off the external MOSFET during the blanking period. PWM duty cycle is determined by the current sense voltage and the voltage at pin COMP.

Threshold of OCP Selection
The threshold voltage level of OCP is selected by the voltage of OCP_TH pin. The OB3330 provides the source current equal to approximately 28uA through OCP_TH pin. So the proper resistor can be connected with the OCP_TH pin to GND in order to generate the voltage needed. If OCP_TH pin is connected with 33K resistor, the threshold voltage of OCP is about 1.8V. If OCP_TH pin is connected with 110K resistor, the threshold voltage of OCP is about 1.5V. If OCP_TH is connected with GND directly, the threshold voltage of OCP is about 2.1V.

<table>
<thead>
<tr>
<th>Voltage of OCP_TH Pin</th>
<th>Connecting State of OCP_TH</th>
<th>Threshold Voltage of OCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>3V</td>
<td>110K</td>
<td>1.5V</td>
</tr>
<tr>
<td>0.9V</td>
<td>33K</td>
<td>1.8V</td>
</tr>
<tr>
<td>0V</td>
<td>GND</td>
<td>2.1V</td>
</tr>
</tbody>
</table>

Zero Current Detection
OB3330 performs zero current detection (ZCD) through ZCD pin by monitoring the voltage activity on the auxiliary windings in series with external resistors. This voltage features a flyback polarity. When the stored energy of the flyback transformer is fully released to the output, the voltage at ZCD pin decreases. When ZCD pin voltage falls below 0.3V, an internal ZCD comparator is triggered and a new PWM switching cycle is initiated following the ZCD triggering.

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 time of approximately 50us.
Maximum Frequency Clamp
According to Transition Mode (TM) Operation principle, the switching frequency is inversely proportional to the output power. Therefore, when the output power decreases, the switching frequency can become rather high without limiting. The maximum switching frequency in OB3330 is internally limited to approximately 300kHz.

Multiplier for Power Factor Correction
The built-in analog multiplier output limits the peak current of primary winding with respect to the AC half wave rectified input voltage. Through controlling the CS comparator threshold as the AC line voltage traverses sinusoidally from zero to peak line voltage, the load appears to be resistive to the AC line and close to unity power factor can be achieved.

Output OVP Protection
An output over-voltage condition is monitored independently by the voltage at pins ZCD. During normal operation, when the voltage at ZCD pin exceeds a threshold of approximately 4.0V, the over-voltage protection function is activated and the GATE is turned off immediately.

VCC OVP and Clamping Protection
VCC is supplied with transformer auxiliary winding output. It is clamped if VCC exceeds 35V. When VCC is higher than 30V, OVP protection is triggered and GATE is shut down, so the device enters power on startup sequence thereafter.

LED String Short Protection
When LED string is short, the positive plateau of auxiliary winding voltage is also near zero and the ZCD voltage is low. If the voltage at ZCD pin is lower than a threshold of approximately 0.9V and lasts more than 10ms, the IC will shut down.

LED String Open Protection
When the LED string open circuit happens, the positive plateau of auxiliary winding voltage increases and the ZCD voltage is high. If the voltage at ZCD pin is higher than a threshold of approximately 4V, OB3330 will shut down and restart again.

Thermal Shutdown
OB3330 provides an on chip thermal shutdown. The IC will stop switching when the junction temperature exceeds the thermal shutdown temperature, typically 140 °C.

Gate Drive Output
OB3330 Gate is connected to an external MOSFET gate for power switch control. Too weak the gate drive strength results in higher conduction and switch loss of MOSFET while too strong gate drive output compromises the EMI. A good tradeoff is achieved through the built-in totem pole gate design with right output strength and dead time control. The low idle loss and good EMI system design is easier to achieve with this dedicated control scheme. The built-in 11V clamp at the gate output protects the MOSFET gate from high voltage stress.
## PACKAGE MECHANICAL DATA

### SOP8 PACKAGE OUTLINE DIMENSIONS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Dimensions In Millimeters</th>
<th>Dimensions In Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.350 - 1.750</td>
<td>0.053 - 0.069</td>
</tr>
<tr>
<td>A1</td>
<td>0.050 - 0.250</td>
<td>0.002 - 0.010</td>
</tr>
<tr>
<td>A2</td>
<td>1.250 - 1.650</td>
<td>0.049 - 0.065</td>
</tr>
<tr>
<td>b</td>
<td>0.310 - 0.510</td>
<td>0.012 - 0.020</td>
</tr>
<tr>
<td>c</td>
<td>0.100 - 0.250</td>
<td>0.004 - 0.010</td>
</tr>
<tr>
<td>D</td>
<td>4.700 - 5.150</td>
<td>0.185 - 0.203</td>
</tr>
<tr>
<td>E</td>
<td>3.800 - 4.000</td>
<td>0.150 - 0.157</td>
</tr>
<tr>
<td>E1</td>
<td>5.800 - 6.200</td>
<td>0.228 - 0.244</td>
</tr>
<tr>
<td>e</td>
<td>1.270 (BSC)</td>
<td>0.050 (BSC)</td>
</tr>
<tr>
<td>L</td>
<td>0.400 - 1.270</td>
<td>0.016 - 0.050</td>
</tr>
<tr>
<td>θ</td>
<td>0° - 8°</td>
<td>0° - 8°</td>
</tr>
</tbody>
</table>
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