

## GENERAL DESCRIPTION

OB3350 is a highly integrated and cost effective Light Emitting Diode (LED) driver optimized for LCD monitor and LCD TV backlighting application. It provides a high performance LED backlight solution with minimized BOM count.

The OB3350 contains a PWM boost driver which uses current mode control and fixed frequency operation to regulate the LED current. The LED current is sensed through an external current sense resistor. The voltage across the sensing resistor is compared with reference level of 300mV, the error is amplified to control the pulse width of the power switch thus to regulate the current flowing the LED.

The OB3350 offers external low frequency PWM (LPWM) dimming method for a wide range of dimming control.

The OB3350 offers comprehensive protection such as power MOSFET over current protection (OCP), output over voltage protection (OVP), IC power supply under voltage lockout (UVLO), and LED open protection.

## FEATURES

- Current Mode PWM Controller With Good Dynamic Response
- 8V to 35V Input Voltage Range
- External PWM Dimming Mode
- Over Voltage Protection
- Over Current Protection
- Under Voltage Lockout (UVLO)
- Thermal Shutdown

## APPLICATIONS

- LCD Monitor
- LCD TV
- Flat panel display

The OB3350 is offered in SOP-8 Packages.

## TYPICAL APPLICATION

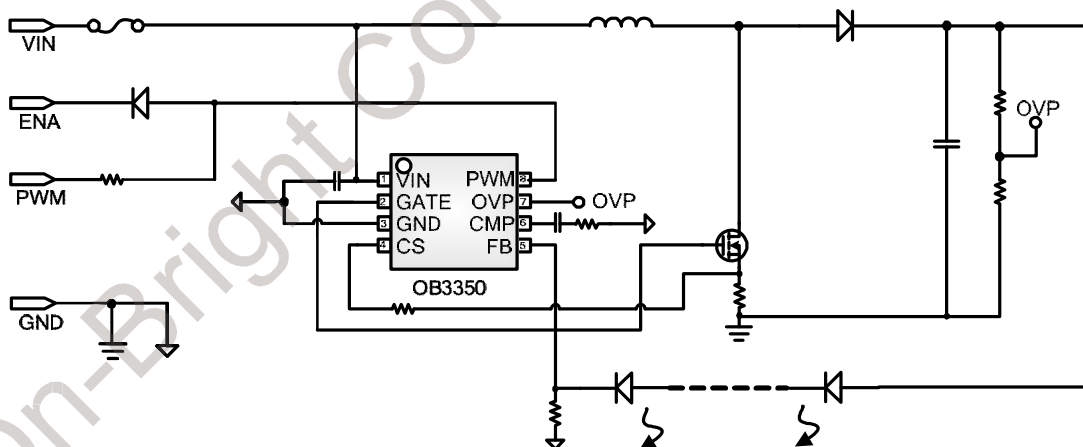


Figure1. OB3350 Typical Application Schematic

### Absolute Maximum Ratings

| Parameter                               | Value         |
|-----------------------------------------|---------------|
| VIN Input Voltage to GND                | -0.3V to 40V  |
| I/O to GND                              | -0.3V to 7V   |
| Operating Ambient Temp. T <sub>A</sub>  | -40°C ~ 85°C  |
| Operating Junction Temp. T <sub>J</sub> | -40°C ~ 150°C |
| Min/Max Storage Temp. T <sub>stg</sub>  | -55°C ~ 150°C |
| Lead Temp. (10 Sec)                     | 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.

### Recommended Operating Range

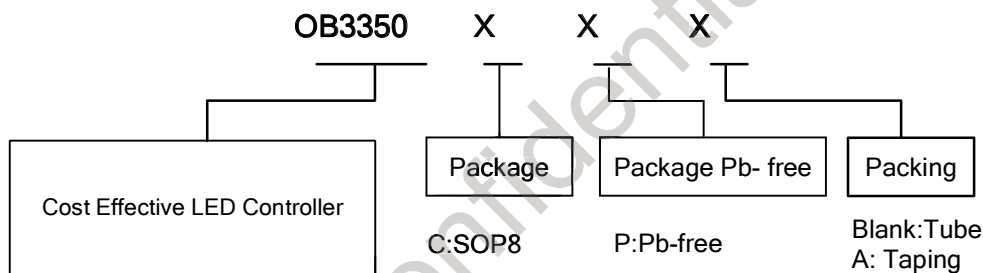
| Parameter               | Value         |
|-------------------------|---------------|
| Vin Voltage             | 8V to 35V     |
| Burst Dimming Frequency | 100Hz to 1KHz |

### Package Thermal Characteristics

| Parameter                                 | Value   |
|-------------------------------------------|---------|
| Thermal Resistance $\theta_{JA}$<br>(SOP) | 150°C/W |

### Ordering Information

| Part Number | Description           |
|-------------|-----------------------|
| OB3350CP    | SOP8, pb-free in tube |
| OB3350CPA   | SOP8, pb-free in T&R  |

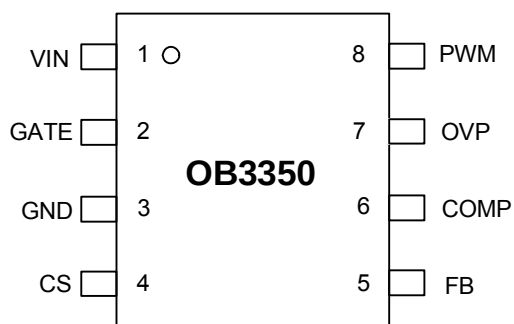


### Package Marking Information



Y:Year Code  
WW:Week Code(01-52)  
ZZZ:Lot Code  
C:SOP8 Package  
P:Pb-free Package  
S:Internal Code(Optional)

### Pin Configuration



| No. | Name | I/O   | Pin Function                          |
|-----|------|-------|---------------------------------------|
| 1   | VIN  | Power | Power Supply Input                    |
| 2   | GATE | I/O   | Gate Driver Output Pin                |
| 3   | GND  | GND   | Ground                                |
| 4   | CS   | I/O   | Current Sense Input                   |
| 5   | FB   | I/O   | LED Current Feedback Input            |
| 6   | COMP | I/O   | Boost Converter Loop Compensation Pin |
| 7   | OVP  | I/O   | Over Voltage Protection Sense Input   |
| 8   | PWM  | I/O   | External PWM Dimming Control          |

### Functional Block Diagram

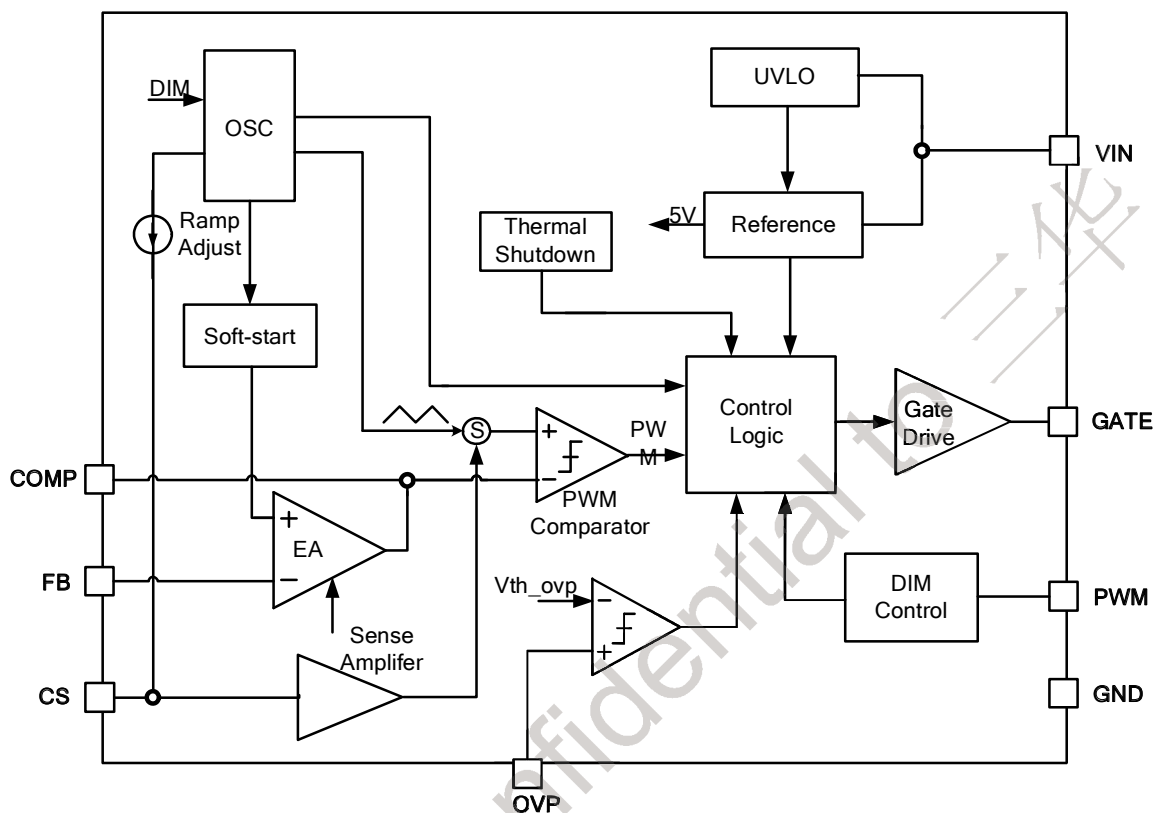


Figure2. OB3350 Functional Block Diagram

### Electrical Characteristics

VDDH=12V, PWM=5V, T<sub>A</sub>=25°C, if not otherwise noted.

| Parameter                | Symbol               | Conditions                               | Min   | Typ | Max   | nits  |
|--------------------------|----------------------|------------------------------------------|-------|-----|-------|-------|
| Current Consumption      |                      |                                          |       |     |       |       |
| Input voltage range      |                      |                                          | 8     | -   | 35    | V     |
| Operating supply current | $I_{VDD}$            | Vin=12V,PWM=5V no load                   | -     | 2.5 | 3     | mA    |
| Stand by current         | $I_{VDD\_STB}$       | PWM low >50ms sleep mode                 | -     | 310 | 400   | uA    |
| VDD UVLO                 |                      |                                          |       |     |       |       |
| UVLO                     | UVLO(ON)             |                                          | 6     | 7   | 8     | V     |
| UVLO Hysteresis          | UVLO(Hys)            |                                          |       | 500 |       | mV    |
| Soft start               |                      |                                          |       |     |       |       |
| Soft start slope         | $I_{sst\_slop}$      |                                          |       | 400 |       | mV/mS |
| PWM Control              |                      |                                          |       |     |       |       |
| Operating frequency      | F <sub>OSC</sub>     |                                          | 175   | 200 | 225   | KHz   |
| Max duty cycle           | D <sub>max</sub>     |                                          | 93    | 95  | 97    | %     |
| PWM Input Threshold      | PWM(high)            | High Level                               |       |     | 2.5   | V     |
|                          | PWM(low)             | Low Level                                | 1.3   |     |       | V     |
| Error Amplifier          |                      |                                          |       |     |       |       |
| Reference voltage        | $V_{ref\_ea}$        | Reference voltage at non-inverting input | 0.289 | 0.3 | 0.311 | V     |
| Open loop voltage gain   | A <sub>m</sub>       |                                          |       | 70  |       | dB    |
| Transconductance of EA   | G <sub>m</sub>       |                                          | 80    | 100 | 120   | uA/V  |
| Output source current    | $I_{source}$         |                                          | 24    | 30  | 36    | uA    |
| Output sink current      | $I_{sin k}$          |                                          | 48    | 60  | 72    | uA    |
| Protection Threshold     |                      |                                          |       |     |       |       |
| OVP                      | V <sub>OVP OV</sub>  | Threshold of output over voltage         | 1.8   | 2.0 | 2.2   | V     |
| OCP                      | V <sub>th_OCP</sub>  | Threshold of over current (duty=90%)     |       | 330 |       | mV    |
| OTP ON                   | T <sub>OTP_ON</sub>  |                                          | 140   | 160 | 180   | °C    |
| OTP OFF                  | T <sub>OTP_OFF</sub> |                                          | 120   | 140 | 160   | °C    |
| Connect detect time      | T <sub>dio</sub>     |                                          |       | 1   |       | mS    |
| OVP UVLO threshold       | V <sub>OVP UV</sub>  | Normal operation                         |       | 200 |       | mV    |
|                          |                      | System startup                           |       | 100 |       | mV    |
| Gate Driver Output       |                      |                                          |       |     |       |       |
| Gate rise time           | T <sub>rise</sub>    | 500pF load                               | -     | 40  | 80    | ns    |
| Gate fall time           | T <sub>fall</sub>    | 500pF load                               |       | 20  | 40    | ns    |

## Function Description

### General Operation

The OB3350 is a LED driver designed for boost DC-DC converters in a constant frequency mode. The controller implements a peak current mode control scheme and an internal transconductance amplifier to accurately control the output current over a wide input and load conditions.

Low frequency PWM dimming input that can accept an external control signal with a duty ratio of 1%-100%. OB3350 offers comprehensive protection features to protect the system in various fault conditions such as output over voltage protection, boost diode disconnection protection and output short circuit protection. The cycle-by-cycle current limit function limits the maximum current flowing through the external MOSFET. The over temperature protection ensures that the system will not run into condition of thermal runaway and blow up.

### Startup

OB3350 is enabled by applying a voltage of greater than approximately 2.5V to PWM pin. An on-chip internal 150k ohm pull down resistor is inserted between PWM pin and ground. When the first rising edge is applied to PWM input, also the pin of PWM is logic high, the OB3350 will power up immediately, and remains power up until the PWM input has been hold low for at least 50ms(typ), at this time the chip will enter sleep mode. At sleep mode, the power of the OB3350 will be lower than 400uA (typ).

Once OB3350 is enabled the internal 5V regulator will be activated to source a current less than 4mA to the whole chip.

When PWM is active high, the OB3350 checks the topology connection first. The chip monitors the OVP pin to see if the Schottky diode (boost diode) is connected or the boost output is short to GND, if the voltage at OVP pin is lower than 100mV, the output will be disabled. The OB3350 will also check other faults (UVLO, OCP and OTP), if there is no fault, then the boost converter will boost up the output with the internal soft start.

### UVLO

An under-voltage lockout protection feature with a hysteresis of about 300mv is provided for VDDH. When the voltage at this pin exceeds a threshold of approximately 7.5V (typ), the IC starts the normal operation. If the voltage at this pin drops below a threshold of approximately 7(typ) V, the IC stops switching operation. The IC resumes

switching operation when the voltage at pin VIN increases to a voltage above 7.5V.

### LED Current Regulation

The LED current is sensed by current sense resistors connected between pin FB and GND. The sensed error signal is amplified and compared to the CS pin sensing current signal plus the slope compensation to determine the on-time of the switching MOSFET. The error amplifier sources or sinks the current to the COMP pin to adjust the required inductor current as the load changes. The slope-compensation signal is added to the current-sense signal to improve the stability at high duty cycles.

The average LED current is approximated by the following equation:

$$I_{LED} [mA] = \frac{300[mV]}{R_{FB} [\Omega]}$$

At light loading, the OB3350 automatically skips some pulses to improve efficiency and prevent overcharging the output capacitor. In this pulse-skipping mode, the inductor current ramps up for a minimum on-time (typical 300ns), then deliver the stored energy to the output. The switch remains off until another pulse is needed to boost the output voltage.

### Slope Compensation

The OB3350 uses a current mode control scheme. The main advantages of current mode control are inherent cycle-by-cycle current limit for the switch and simpler control loop characteristics. However, current mode control has an inherent instability for duty cycles greater than 50%, which is also called sub-harmonic oscillation. The OB3350 has a build-in slope compensation to avoid sub-harmonic oscillation.

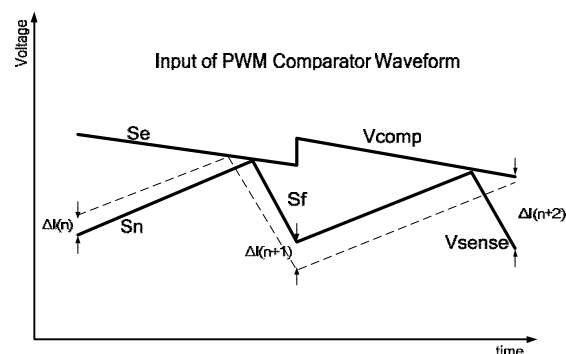


Figure4 Sub-harmonic oscillation at duty>50% and compensation slope to avoid sub-harmonic oscillation

If the control signal (which applied to the negative input of the PWM comparator) has no slope and

the slope which representing inductor current ramp up until the comp signal is reached, then ramp down. If the duty > 50%, any distribution won't be converged from duty to duty and thus sub-harmonic oscillation happens. For the equation below:

$$\Delta I_{(n+1)} = \frac{S_f - S_e}{S_n + S_e} \Delta I_{(n)}$$

To avoid sub-harmonic oscillation happening, just make sure  $(S_f - S_e) / (S_n + S_e)$  smaller than 1. For boost applications, the slopes  $S_e$ ,  $S_f$  and  $S_n$  can be calculated with the formulas below and a typical value of  $V_{SL}$  is 50mV.

$$S_e = V_{SL} \times f_s$$

$$S_f = R_{sen} \times (V_{out} - V_{in}) / L$$

$$S_n = R_{sen} \times V_{in} / L$$

When  $S_e$  increases, then the factor which can determine whether the sub-harmonic oscillation will occur decreases. When the duty cycle is greater than 50% and the inductance becomes less, the factor increases. And for more flexibility slope compensation amplitude can be increased by adding one external resistor,  $R_{SL}$ , in the CS path. Figure 4 shows the setup. The externally generated slope compensation is then added to the internal slope compensation of the OB3350. When using external slope compensation, the formula for  $S_e$  becomes:

$$S_e = (V_{SL} + I_s \times R_{SL}) \times f_s$$

A typical value of  $I_s$  is 40uA.

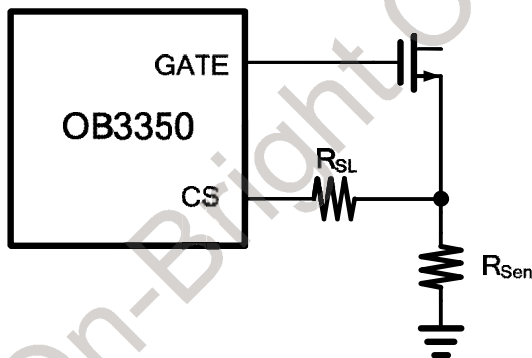


Figure5 Adding external slope compensation to OB3350

It's good design practice to only add as much slope compensation as needed to avoid sub-harmonic oscillation. Additional slope compensation minimized the influence of the sensed current in the control loop. With very large slope compensation the control loop characteristics are similar to a voltage mode regulator which compares the error voltage to a saw tooth waveform rather than the inductor current.

## Dimming Control

The LED brightness is controlled by the PWM signal at PWM pin which has different duty cycle. OB3350 can accept an external PWM signal to PWM pin in the range of 100Hz to 1 KHz with a swing voltage of 0V to a level greater than 2.5V.

## OVP Protection

OB3350 shuts down the output if the output voltage is higher than the predetermined threshold level. In case of LED failing, the current of LED and the resulted voltage drop on sensing resistor is nearly zero; the converter will run at maximum duty cycle that boosts the output voltage to a very high level. To prevent this happen, the output voltage is monitored through Pin OVP and converter is shut down if the output voltage exceeds the predetermined level. This protection is latched and OB3350 can be reset from VIN or PWM.

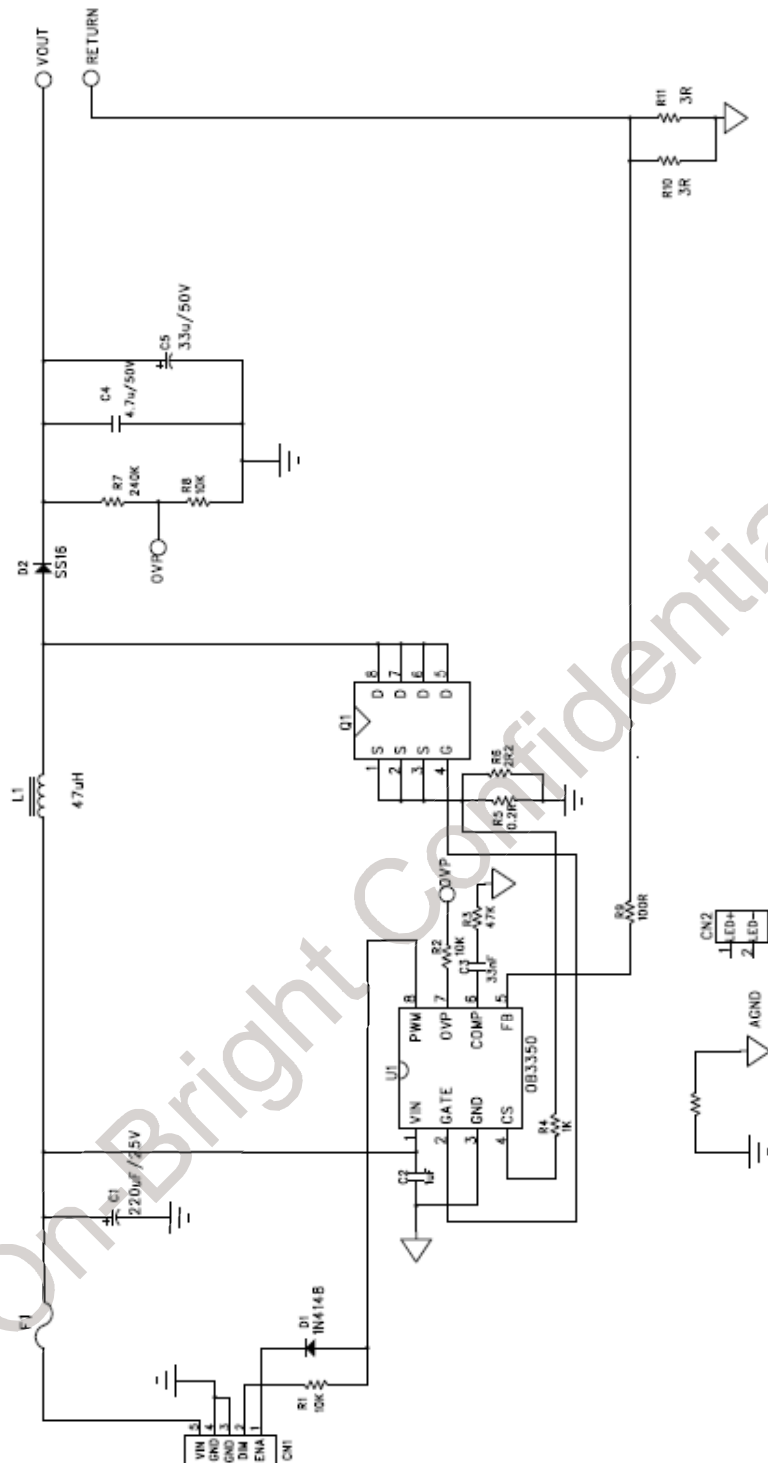
## VOUT SHORT Protection

VOUT short condition is monitored by the voltage at pins OVP. During normal operation, when the voltage at OVP pin drops below a threshold of approximately 0.2V, the VOUT-short protection function is activated and the GATE is turned off. This state is latched and can be reset from VIN or PWM.

## Thermal Shutdown

The OB3350 includes a thermal protection circuit. When the junction temperature exceeds 160°C (typical), the controller and current sources shut down and do not restart until the junction temperature drops below 140°C (typical).

### Reference Application



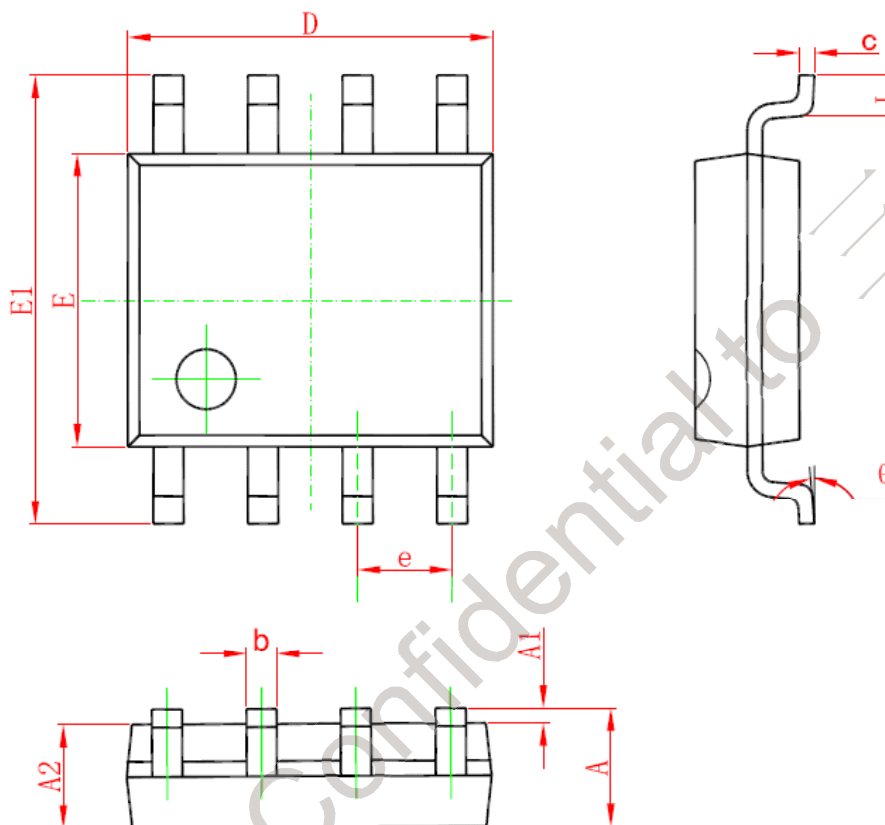
VIN: 10.8-13.2V  
LPWM: 100%, Max. Brightness; 0%Min. Brightness  
NA: Disable, 0-0.8V; Enable, 2-5V

Figure6. OB3350 for external LPWM dimming Reference Application Schematic



## 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 |
| $\theta$ | 0°                        | 8°    | 0°                   | 8°    |

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