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

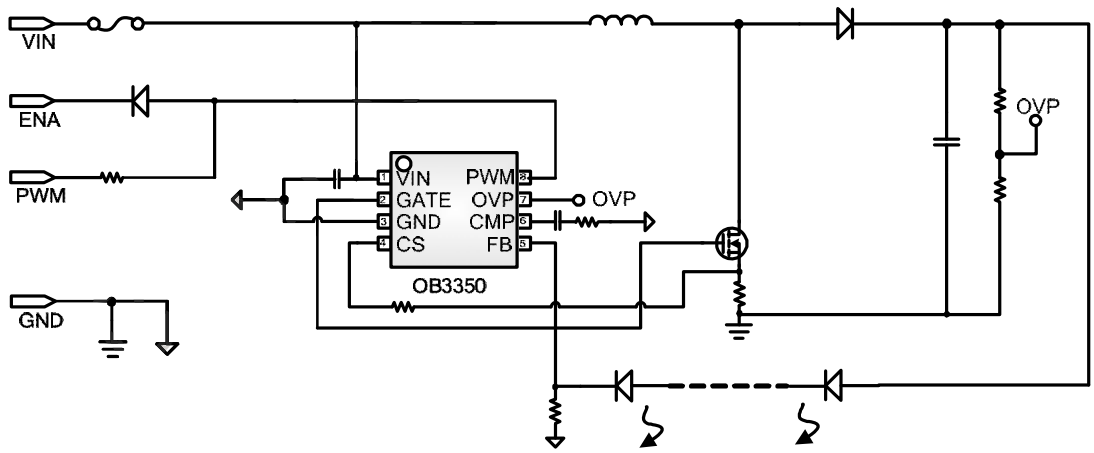


Figure1. OB3350 Typical Application Schematic

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_A	-40℃ ~ 85℃
Operating Junction Temp. T_J	-40℃~ 150℃
Min/Max Storage Temp. T_{stg}	-55℃ ~150℃
Lead Temp. (10 Sec)	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.

Recommended Operating Range

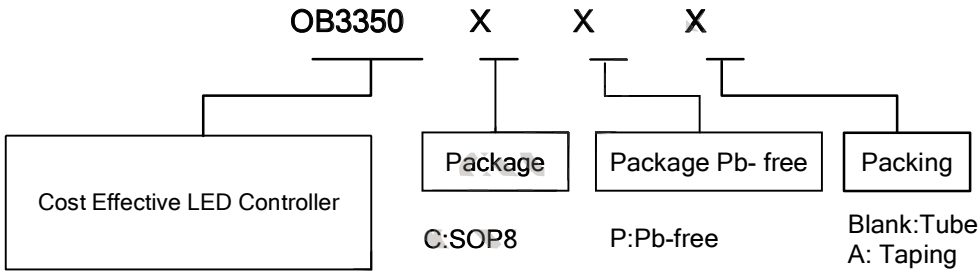
Parameter	Value
Vin Voltage	8V to 35V
Burst Dimming Frequency	100Hz to 1KHz

Package Thermal Characteristics

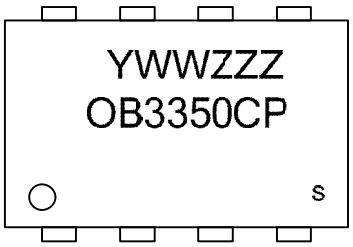
Parameter	Value
Thermal Resistance θJA (SOP)	150℃/W

Ordering Information

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

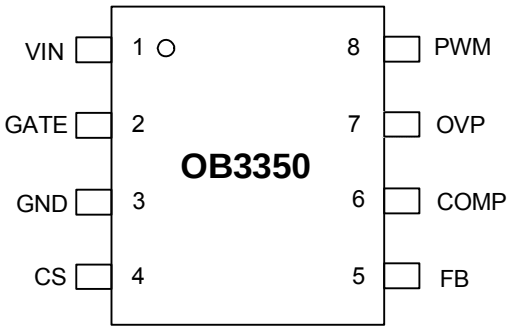


Package Marking Information



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

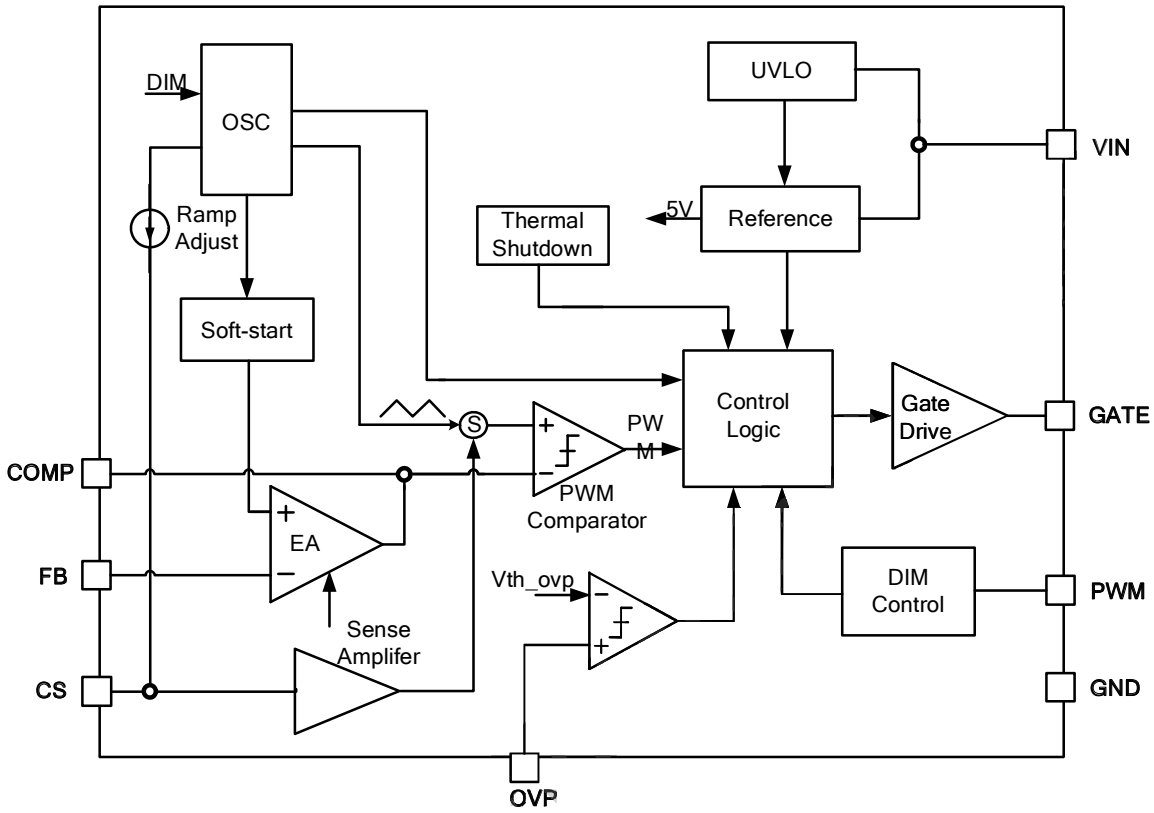


Figure2. OB3350 Functional Block Diagram

Electrical Characteristics

VDDH=12V,PWM=5V, T_A=25℃, if not otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
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_{OSC}		175	200	225	KHz
Max duty cycle	D_{max}		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_m			70		dB
Transconductance of EA	Gm		80	100	120	uA/V
Output source current	I_{source}		24	30	36	uA
Output sink current	I_{sink}		48	60	72	uA
Protection Threshold						
OVP	$V_{OVP\ OV}$	Threshold of output over voltage	1.8	2.0	2.2	V
OCP	V_{th_OCP}	Threshold of over current protection (duty=90%)		330		mV
OTP ON	T_{OTP_ON}		140	160	180	℃
OTP OFF	T_{OTP_OFF}		120	140	160	℃
Connect detect time	T_{dio}			1		mS
OVP UVLO threshold	$V_{OVP\ UV}$	Normal operation		200		mV
		System startup		100		mV
Gate Driver Output						
Gate rise time	T_{rise}	500pF load	-	40	80	ns
Gate fall time	T_{fall}	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 theOB3350 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.

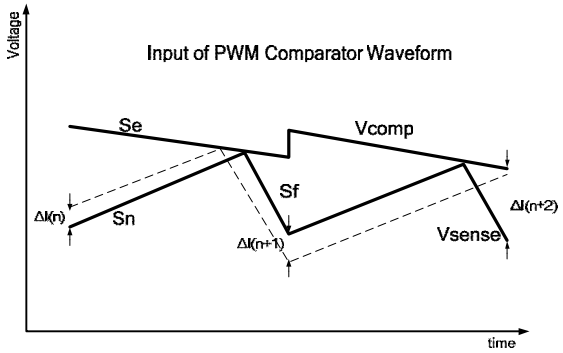


Figure4 Sub-harmonic oscillation at duty>50% and compensation slope to avoid sub-harmonic oscillation
If the control signal (which applied to the negative input of the PWM comparator) has no slope and

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 Se, Sf and Sn can be calculated with the formulas below and a typical value of VSL 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 Se 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, RSL, 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 Se becomes:

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

A typical value of I_s is 40uA.

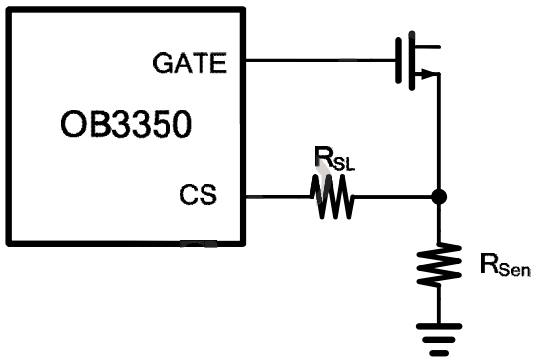


Figure5 Adding external slope compensation to OB3350

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

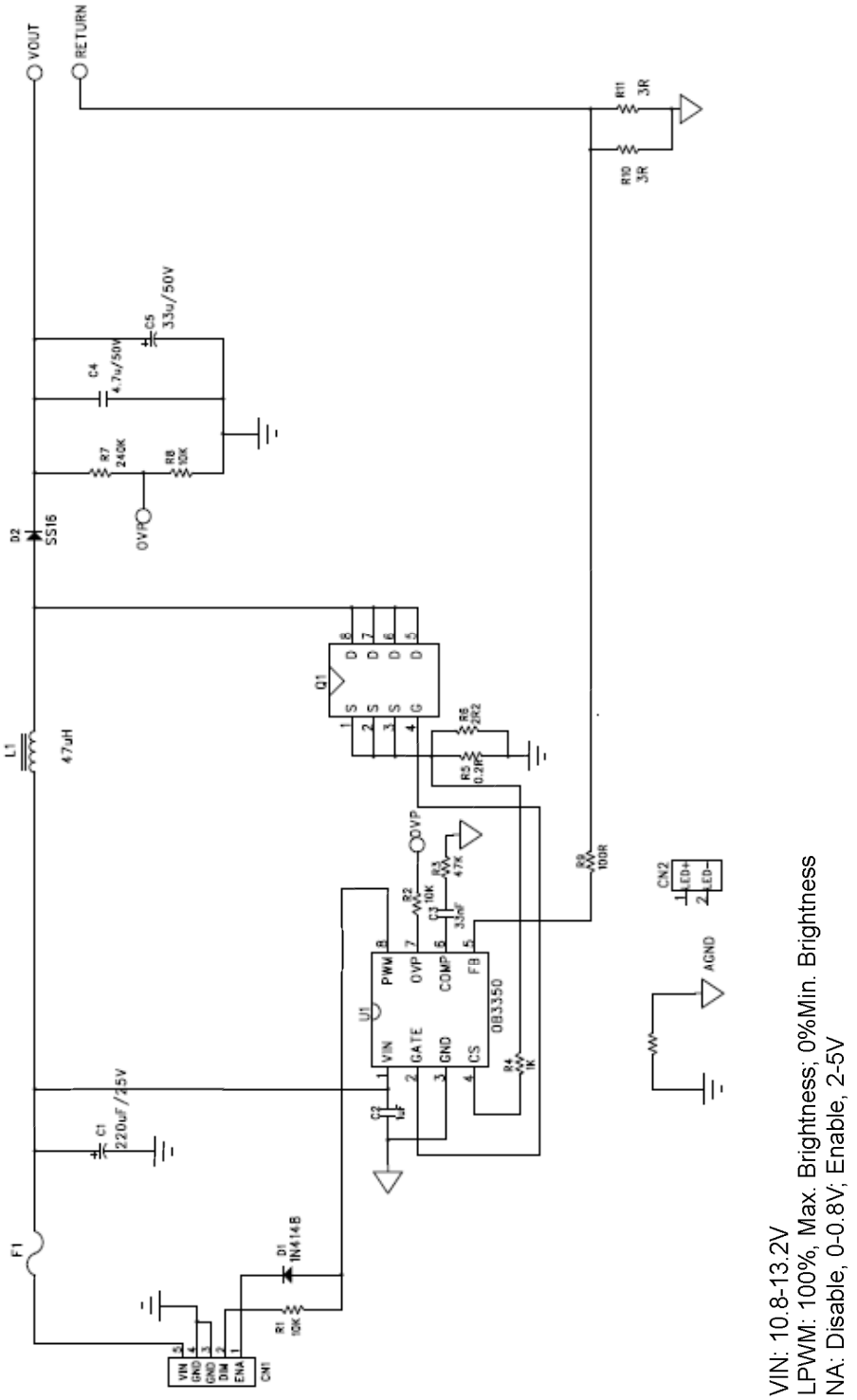
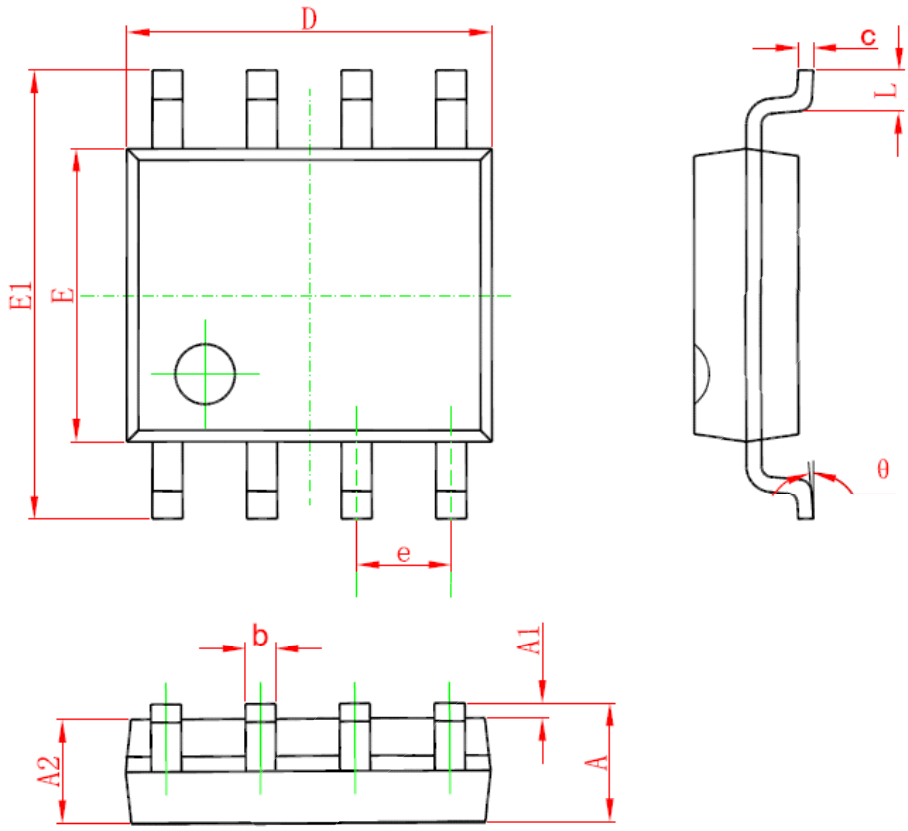


Figure6. OB3350 for external LPWM dimming Reference Application Schematic

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
θ	0°	8°	0°	8°

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