GENERAL DESCRIPTION

OB3353A 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 OB3353A 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 400mV, the error is amplified to control the pulse width of the power switch thus to regulate the current flowing the LED.

The OB3353A offers PWM to analog dimming method for a wide range of dimming control.

The OB3353A offers comprehensive protection such as power MOSFET over current protection (OCP), output over voltage protection (OVP), Diode & Inductor short protection, LED cathode short to GND protection, IC power supply under voltage lockout (UVLO), and LED open protection.

FEATURES

- Current Mode PWM Controller With Good Dynamic Response
- 9V to 30V Input Voltage Range
- PWM to analog Dimming Mode
- Over Voltage Protection
- Over Current Protection
- Under Voltage Lockout (UVLO)
- Thermal Shutdown
- Diode & Inductor Short Protection
- LED cathode short to GND Protection

APPLICATIONS

- LCD Monitor
- LCD TV
- Flat panel display

The OB3353A is offered in SOP-8 Packages.
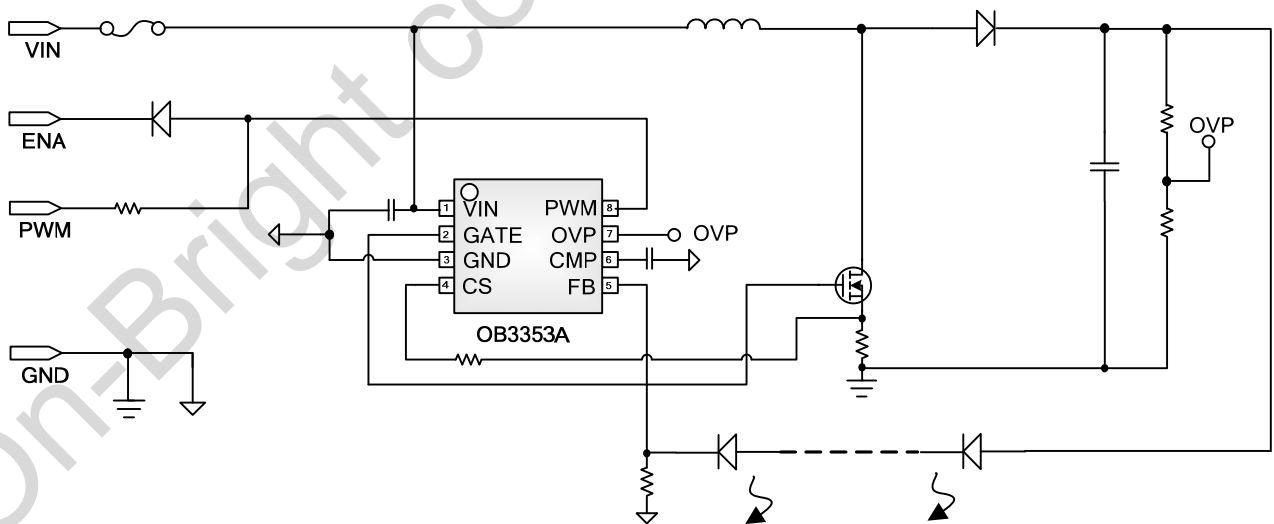
TYPICALICAL APPLICATION

Figure1. OB3353A Typical Application Schematic

Absolute Maximum Ratings

Parameter	Value
VIN, GATE，OVP to GND	-0.3V to 33V
CS^2, FB^2, COMP, ^{2} PWM $^{2/3}$ 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℃

Note1: 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.

Note2: Rating value refers to DC only. For small duty cycle pulse in less than 500ns in one period (typical 8.33uS), negative spike value is relaxed to -2V.

Note3: Rating value refers to DC only. For small duty cycle pulse in less than 100ns in one period (typical 8.33us), negative spike value is relaxed to -5V.
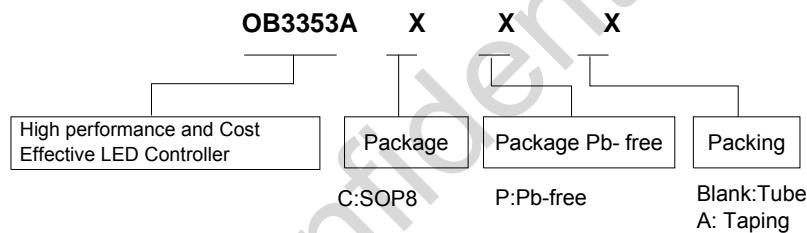
Recommended Operating Range

Parameter	Value
VIN Voltage	9V to 30V
PWM Frequency for analog Dimming	5KHz to 50KHz

Package Thermal Characteristics

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

Ordering Information

Part Number	Description
OB3353ACP	SOP8, Pb-free in tube
OB3353ACPA	SOP8, Pb-free in T&R

OB3353A   X   X   X

High performance and Cost Effective LED Controller	Package	Package Pb- free	Packing
	C:SOP8	P:Pb-free	Blank:Tube A: Taping

Marking Information

YWWZZZ
OB3353CP
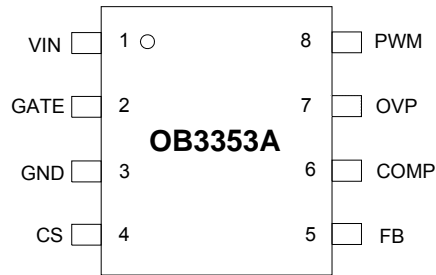A

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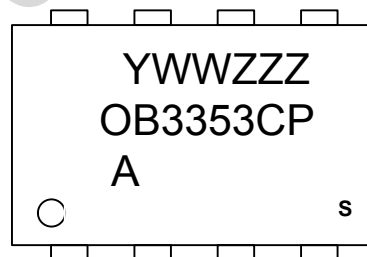
Y:Year Code
WW:Week Code(01-52)
ZZZ:Lot Code
C:SOP8 Package
P:Pb-free Package
A:Character Code
S:Internal Code(Optional)

Pin Configuration

```
        ┌──────────────────┐
VIN ──┤ 1 ○            8 ├── PWM
        │                  │
GATE ──┤ 2            7 ├── OVP
        │    OB3353A       │
GND ──┤ 3            6 ├── COMP
        │                  │
 CS ──┤ 4            5 ├── FB
        └──────────────────┘
```

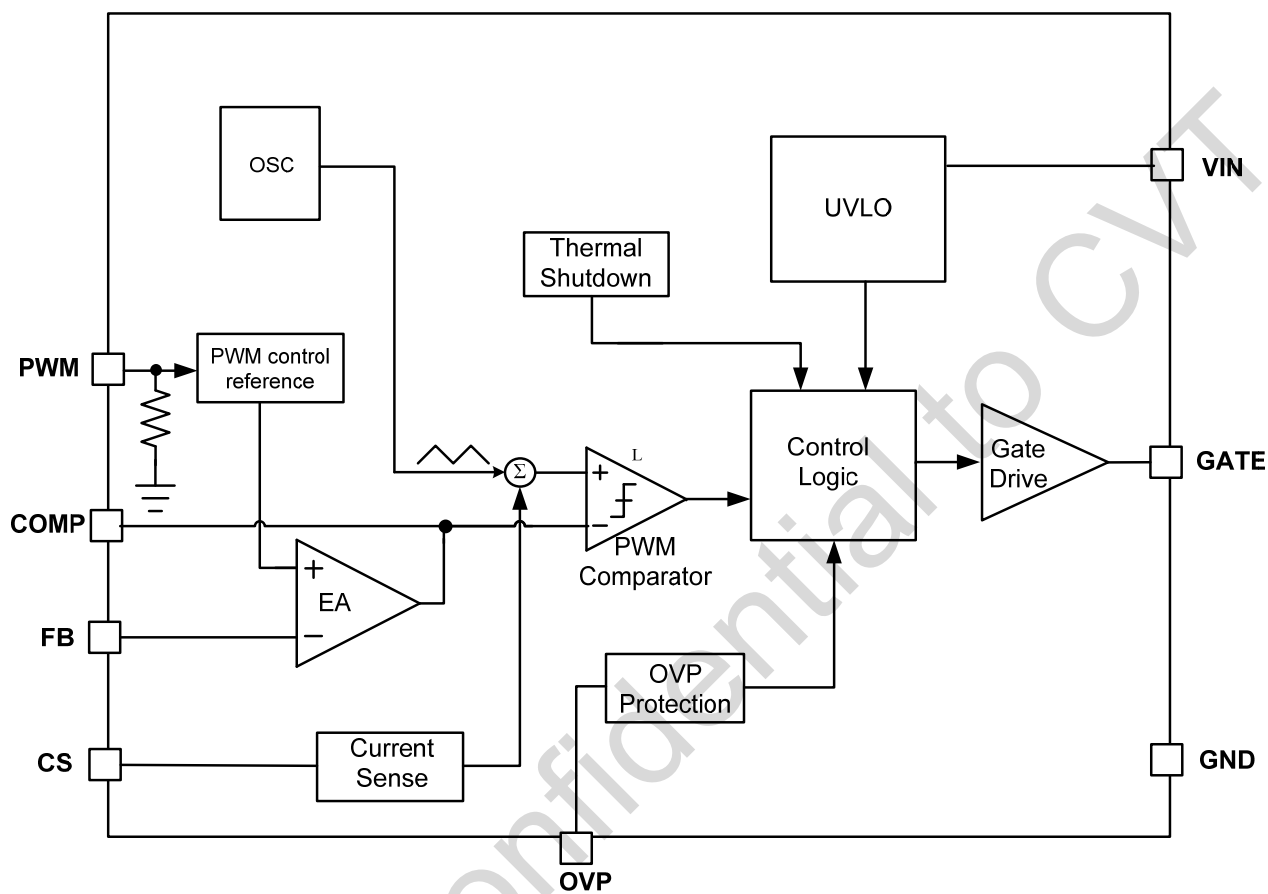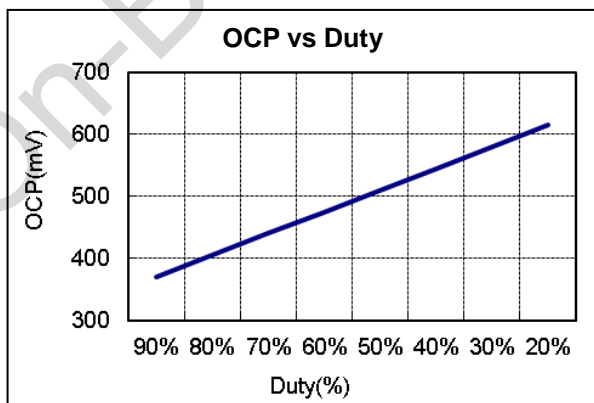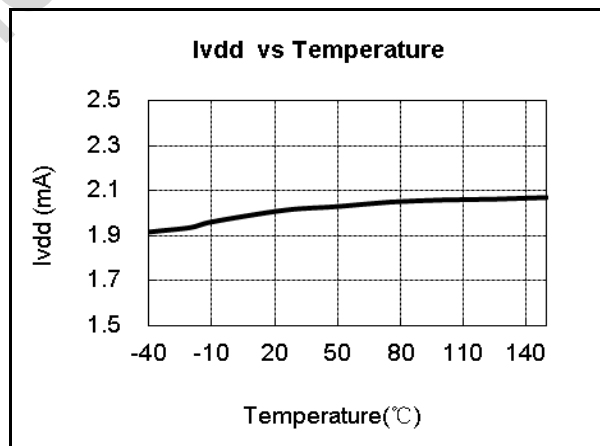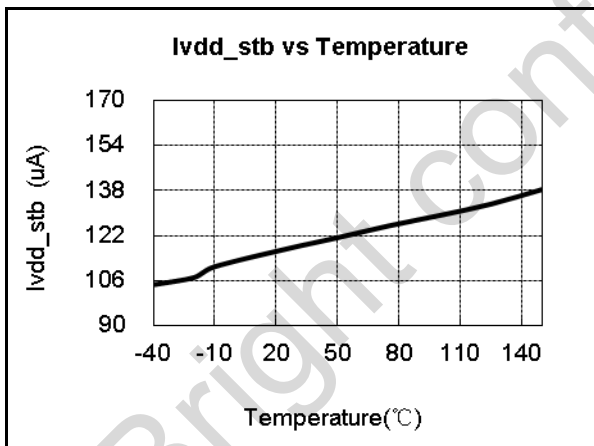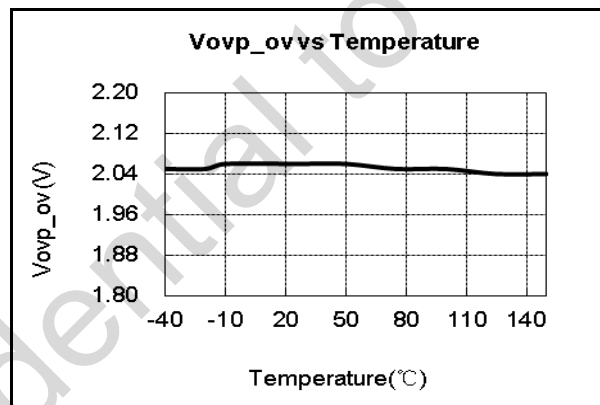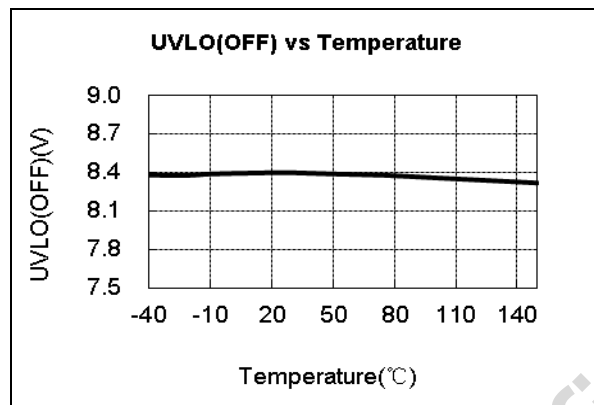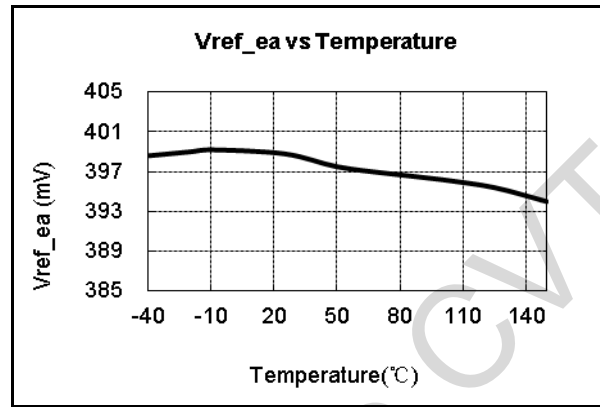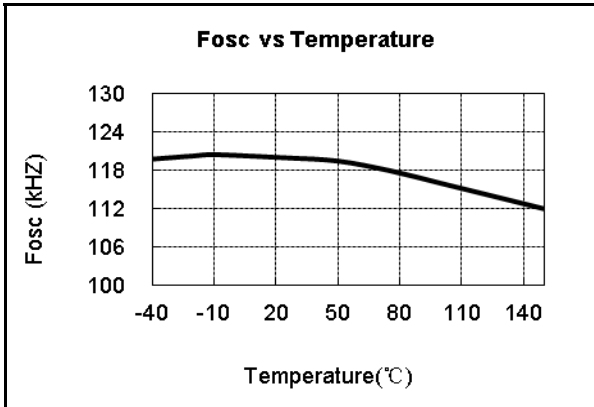| No.	Name	I/O	Pin Function
1	VIN	Power	Power Supply Input
2	GATE	Output	Gate Driver Output Pin
3	GND	Power	Ground
4	CS	I/O	Current Sense Input
5	FB	Input	LED Current Feedback Input
6	COMP	I/O	Boost Converter Loop Compensation Pin
7	OVP	Input	Over Voltage Protection Sense Input
8	PWM	Input	PWM signal input pin for analog dimming control

Functional Block Diagram

Figure2. OB3353A Functional Block Diagram

Electrical Characteristics

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

Parameter	Symbol	Conditions	Min	Typical	Max	Units
Current Consumption						
Input voltage range			9	-	30	V
Operating supply current	I_{VDD}	Vin=12V,PWM=5V no load	-	2	3	mA
Stand by current	I_{VDD_STB}	PWM low >50ms sleep mode	-	130	180	uA
VDD UVLO						
UVLO	UVLO(OFF)		7.8	8.3	8.8	V
UVLO Hysteresis	UVLO(Hys)			800		mV
Soft start						
Soft start slope	I_{sst_slop}			22		mV/ms
PWM Control						
Operating frequency	F_{OSC}		110	120	130	KHz
Max duty cycle	D_{max}		93	95	97	%
Error Amplifier						
Reference voltage	V_{ref_ea}	Reference voltage at non-inverting input	392	400	408	mV
Open loop voltage gain	A_m			70		dB
Transconductance of EA	Gm			100		uA/V
Output source current	I_{source}			30		uA
Output sink current	I_{sink}			60		uA
PWM to Analog Dimming Control						
PWM duty			0	-	100	%
PWM Logic input level	high		2.5			V
	low				1.3	V
Protection Threshold						
OVP	V_{OVP_OV}	Threshold of output over voltage	1.9	2.0	2.1	V
OCP	V_{th_OCP}	Threshold of over current protection (duty=90%)	260	380	500	mV
OTP ON	T_{OTP_ON}			160		℃
CS high protection threshold	VTH_CS	Diode or Inductor short	1.1	1.2	1.3	V
CMP high protection threshold	VTH_CMP	FB short to GND	2.9	3.2	3.5	V
OVP UVLO threshold	V_{OVP_UV}	Normal operation		250		mV
		System startup		150		mV
Gate Driver Output						
Gate rise time	T_{rise}	1nF load	-	40		ns
Gate fall time	T_{fall}	1nF load		20		ns

CHARACTERIZATION PLOTS

Fosc vs Temperature

Vref_ea vs Temperature

UVLO(OFF) vs Temperature

Vovp_ov vs Temperature

Ivdd_stb vs Temperature

Ivdd vs Temperature

OCP vs Duty

Function Description

General Operation

The OB3353A 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. The transconductance amplifier reference is set by internal reference voltage and the PWM duty cycle at PWM pin.

OB3353A offers comprehensive protection features to protect the system in various fault conditions such as LED open protection, output over voltage protection (OVP), the cathode of LED short to GND protection(CMP high), Diode & Inductor short protection(CS high). 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

OB3353A is enabled by applying a voltage of greater than approximately 2.5V to PWM pin. An on-chip internal 220KΩ pull down resistor is inserted between PWM pin and ground. When the first rising edge is applied to PWM input, the OB3353A will power up immediately, and remains power up until the PWM input is lower than 1.3V for at least 20ms(typical), at this time the chip will enter standby mode. At standby mode, the power of theOB3353A will be lower than 130uA (typical).

Once OB3353A 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 OB3353A 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 150mV, the output will be disabled. The OB3353A will also check other faults (UVLO, CS high, CMP high, FB high, 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 800mv is provided for VIN. When the voltage at this pin exceeds a threshold of approximately 8.3V (typical), the IC starts the normal operation. If the voltage at this pin drops below a threshold of approximately 7.5V (typical), the IC stops switching operation. The IC resumes switching operation when the voltage at pin VIN increases to a voltage above 8.3V (typical).

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 error amplifier reference is set by internal reference voltage and the PWM duty cycle at PWM pin.

The average LED current is approximated by the following equation：

$$I_{LED}[mA] = \frac{400 * DUTY_{PWM}[mV]}{R_{FB}[\Omega]}$$

At light loading, the OB3353A automatically skips some pulses to improve efficiency and prevent over charging the output capacitor. In this pulse-skipping mode, the inductor current ramps up for a minimum on-time (typical 600ns), then deliver the stored energy to the output. The switch remains off until another pulse is needed to boost the output voltage.

Dimming Control

The LED brightness is controlled by the PWM signal at PWM pin which has different duty cycle. OB3353A can accept an external PWM signal to PWM pin in the range of 5KHz to 50KHz with a swing voltage of 0V to a level greater than 2.5V.

An internal square wave whose duty cycle is the same as the duty cycle of the external PWM signal to PWM pin is filtered to provide reference voltage of EA input which determines the FB reference.

Slope Compensation

The OB3353A 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 OB3353A has a build-in slope compensation to avoid sub-harmonic oscillation.
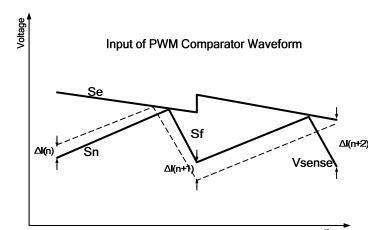

Figure2 Sub-harmonic oscillation at duty>50% and compensation slope to avoid sub-harmonic oscillation

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 3 shows the setup. The externally generated slope compensation is then added to the internal slope compensation of the OB3353A. When using external slope compensation, the formula for Se becomes:

$$S_e = (V_{SL} + I_s \times R_{SL}) \times f_s$$
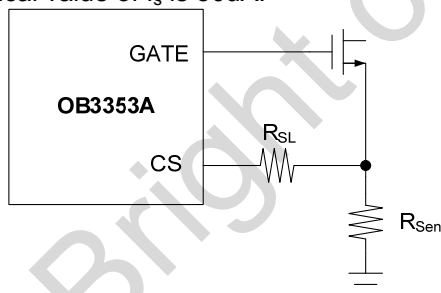
A typical value of I_s is 50uA.

Figure3. Adding external slope compensation to OB3353A

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.

LED Open Protection
OB3353A 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 OB3353A can be reset from VIN or PWM.

LED Cathode Short to GND Protection
When LED cathode is shorted to GND, the boost converter will continuously increase the output to OVP to shut down gate output. But in some condition, if the output is power limited by OCP protection before the output reach the OVP voltage, the gate can never be turned off, in this case large current will go through both Schottky diode and MOSFET, and cause permanent damage. OB3353A will monitor the voltage on COMP pin, if the voltage on COMP pin is continuously greater than 3.2V (typical) for 37ms (typical). The gate output will be latched off for the safe propose.

Diode & Inductor Short Protection
When the Schottky diode or the inductor shorts, the current of the power MOSFET increasing significantly, which will cause the MOSFET permanent damage if the IC is continuously working. OB3353A will monitor the voltage on CS pin voltage cycle by cycle, if the voltage on CS pin is greater than 1.2V (typical) for continuous 17 cycles. The IC will latch shutdown the gate output to prevent the MOSFET from permanent damage.

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 0.25V (typical), the Vout short protection function is activated and the GATE is turned off.
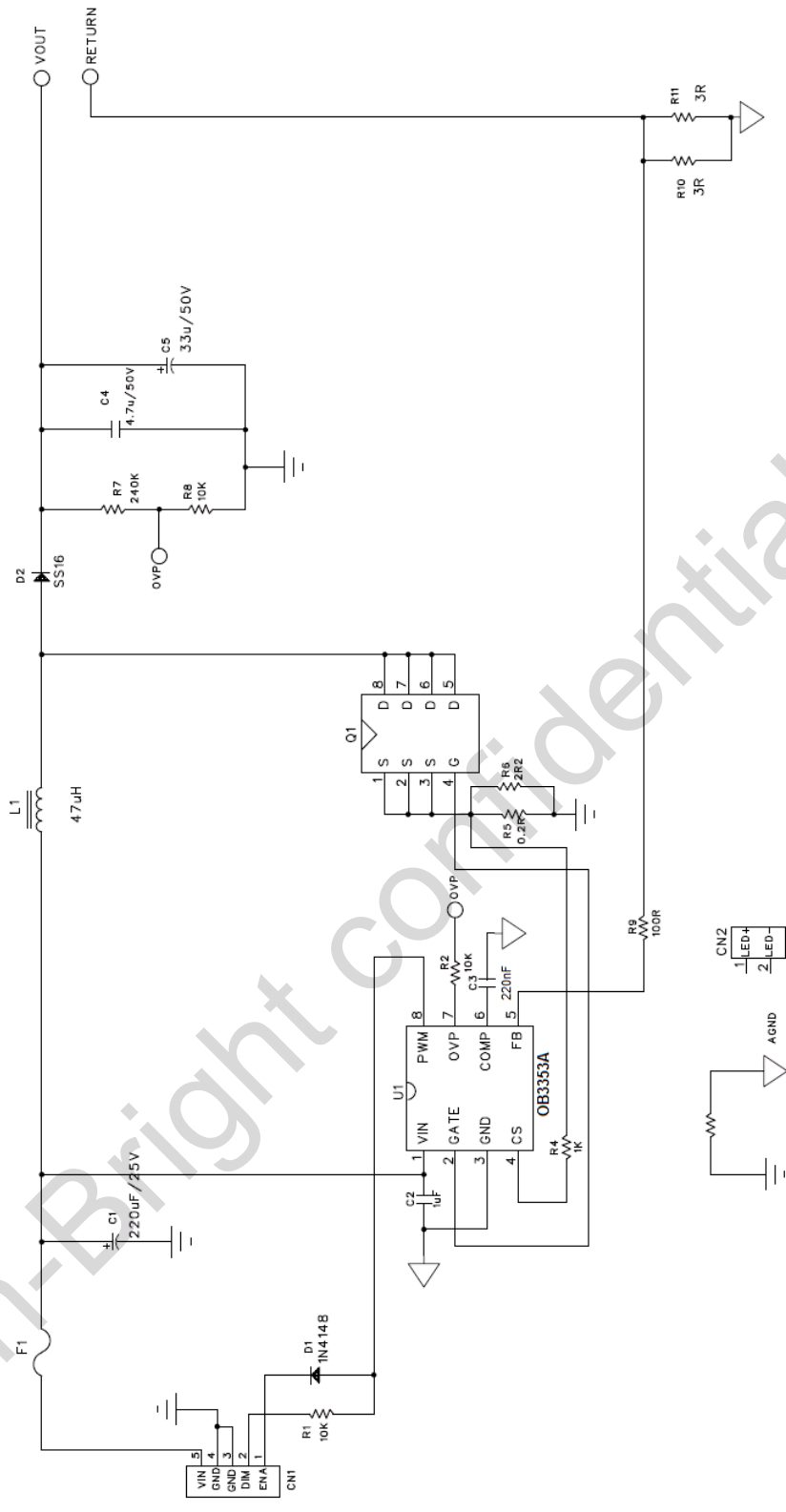This state is latched and can be reset from VIN or PWM.

Thermal Shut Down
The OB3353A includes a thermal protection circuit. When the junction temperature exceeds 160℃ (typical), the controller and current sources latch shut down.
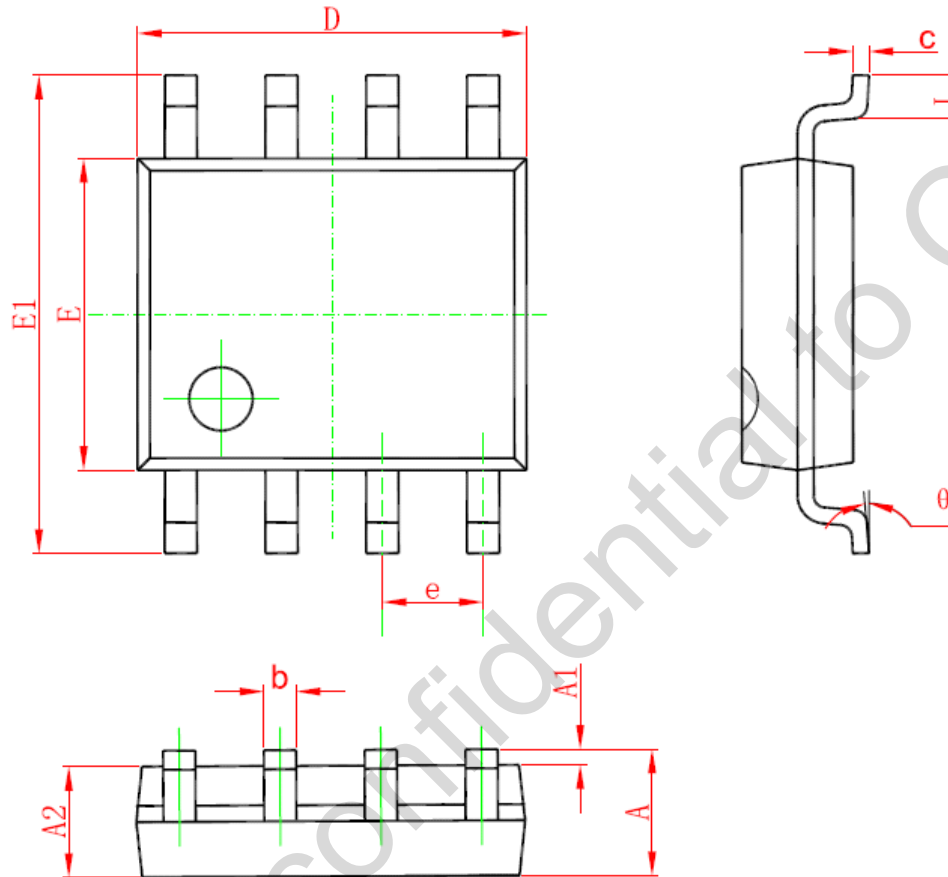
Reference Application

Figure5. OB3353A for HPWM to analog dimming Reference Application Schematic

VIN: 10.8-13.2V
HPWM: 100%, Max. Brightness; 1%Min. Brightness
NA: Disable, 0-0.8V; Enable, 2-5V

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	0º	8º	0º	8º

Important Notice

Right to make changes

On-Bright Electronics Corp. reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

Warranty information

On-Bright Electronics Corp. warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with its standard warranty. Testing and other quality control techniques are used to the extent it deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

On-Bright Electronics Corp. assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using On-Bright's components, data sheet and application notes. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

Life support

On-Bright Electronics Corp.'s products are not designed to be used as components in devices intended to support or sustain human life. On-bright Electronics Corp. will not be held liable for any damages or claims resulting from the use of its products in medical applications.

Military

On-Bright Electronics Corp.'s products are not designed for use in military applications. On-Bright Electronics Corp. will not be held liable for any damages or claims resulting from the use of its products in military applications.