GENERAL DESCRIPTION

The OB3363T is a highly integrated and high performance LED driver that optimized for LCD backlight application. It integrates a boost driver and 4 channels of current balancer that optimized to drives multi LED arrays, and thus provides a high performance LED backlight solution with minimized BOM count.

The OB3363T contains a PWM boost driver which uses current mode control and fixed frequency operation. The operation frequency can be programmed by setting external resistor value at RI pin.

The OB3363T integrates 4 channels current balancer with up to 170mA current capability per channel and it achieves 3% matching accuracy among LED strings. The minimum voltage of current source is regulated to as lower as 350mV so that benefits the efficiency and improve the IC thermal performance.

The OB3363T supports direct PWM dimming and PWM to analog dimming which allows flexible control of the backlight luminance. The LED current is directly modulated by PWM duty cycle on DIM pin.

OB3363T is offered in 16-pin SOP/ESOP/ TSSOP

FEATURES

- 10V gate drive, better MOS compatibility
- High efficiency and compact size
- 6V to 40V input voltage range
- 3% matching accuracy between 4 LED strings control currents
- 100KHz~600KHz operating frequency
- Direct PWM dimming and PWM to analog dimming
- Very low standby power
- Programmable over voltage protection
- Under voltage lockout(UVLO)
- LED string open/short protection
- LED cathode node to ground short protection
- Inductor/diode short protection
- Over temperature protection (OTP)

APPLICATIONS

- LCD Monitor
- LCD TV
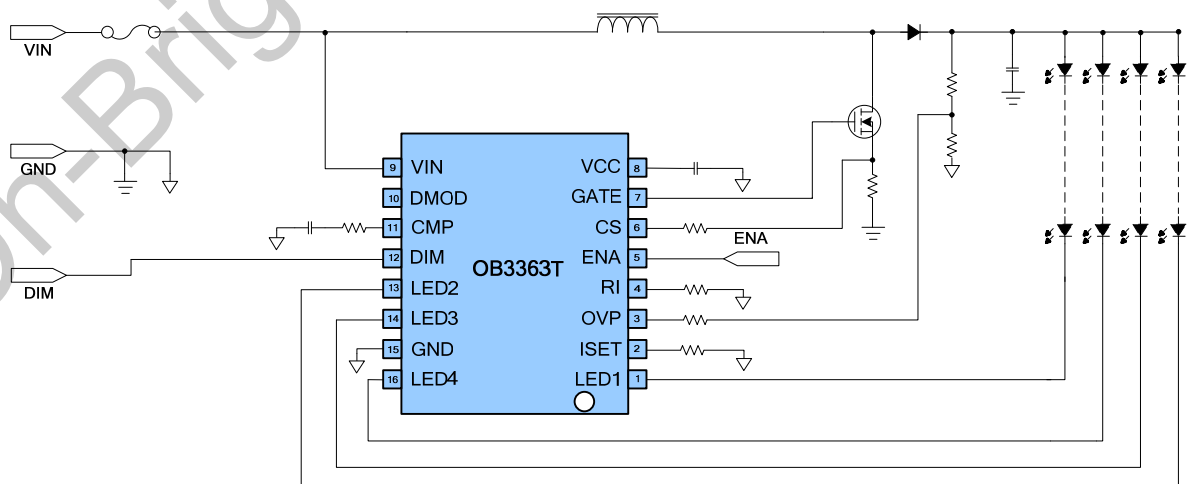- Flat panel display

TYPICAL APPLICATION

Figure1: OB3363T Typical Application Schematic

Absolute Maximum Ratings

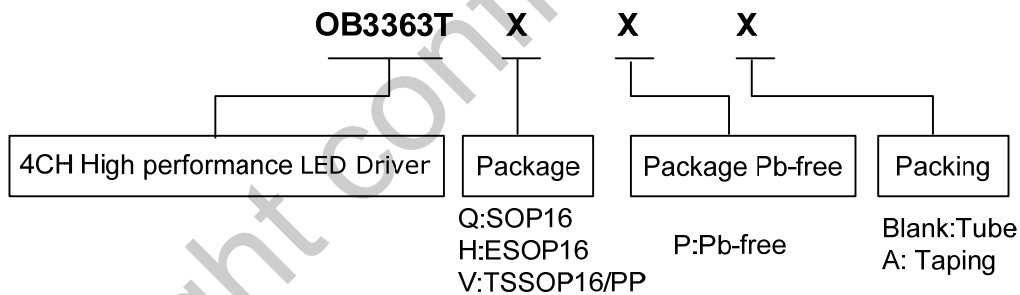| Parameter	Value
Vin Input Voltage to GND	-0.3V to 60V
LEDX to GND	-0.3V to 60V
I/O to GND	-0.3V to 7V
Operating Ambient Temp. T_A	-20℃ ~ 85℃
Operating Junction Temp. T_J	150℃
Min/Max Storage Temp. T_{stg}	-55℃ ~150℃
Lead Temp. (10 Sec)	260 ℃

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	6V to 40V
Operating Frequency	100KHz to 600kHz
PWM to analog Dimming Frequency	15KHz to 60kHz
External LPWM Frequency	100Hz to 5kHz
LEDX Current	60mA to170mA

Ordering Information

Part Number	Description
OB3363TQP	SOP16, Pb-free in Tube
OB3363TQPA	SOP16, Pb-free in T&R
OB3363THP	ESOP16, Pb-free in Tube
OB3363THPA	ESOP16, Pb-free in T&R
OB3363TVP	TSSOP16/PP, Pb free in Tube
OB3363TVPA	TSSOP16/PP, Pb free in T&R

OB3363T   X   X   X

4CH High performance LED Driver	Package	Package Pb-free	Packing

Q:SOP16
H:ESOP16
V:TSSOP16/PP

P:Pb-free

Blank:Tube
A: Taping

Marking Information

YWWZZZ **OB3363HP** **T** ○ **S**	**YWWZZZ** **OB3363QP** **T** ○ **S**	**YWWZZZ** **OB3363VP** **T** ○ **S**

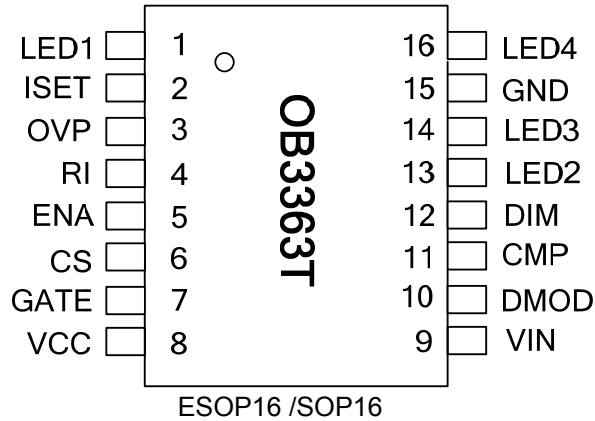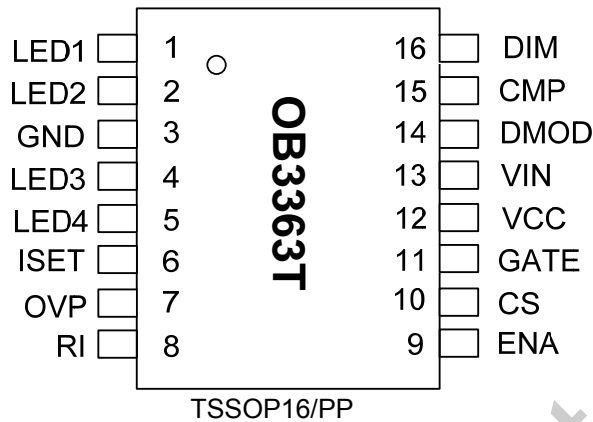|		
Y: Year Code WW: Week Code (01-52) ZZZ:Lot Code H: ESOP16 Package P: Pb-free Package T: Character Code S: Internal Code	Y: Year Code WW: Week Code (01-52) ZZZ:Lot Code Q: SOP16 Package P: Pb-free Package T: Character Code S: Internal Code	Y: Year Code WW: Week Code (01-52) ZZZ:Lot Code V: TSSOP16/PP Package P: Pb-free Package T: Character Code S: Internal Code

Pin Configuration for OB3363TQP/OB3363THP

```
          ┌─────────────────┐
LED1 ┌─┐  1    ○          16  ┌─┐ LED4
ISET ┌─┐  2               15  ┌─┐ GND
OVP  ┌─┐  3     O          14  ┌─┐ LED3
RI   ┌─┐  4     B          13  ┌─┐ LED2
ENA  ┌─┐  5     3          12  ┌─┐ DIM
CS   ┌─┐  6     3          11  ┌─┐ CMP
GATE ┌─┐  7     6          10  ┌─┐ DMOD
VCC  ┌─┐  8     T           9  ┌─┐ VIN
          └─────────────────┘
```

ESOP16 /SOP16

Terminal Assignment for OB3363TQP/OB3363THP

Number	Pin Name	I/O	Pin Function
1	LED1	I/O	LED string current input
2	ISET	I/O	Set the output current of every channels by external resistor
3	OVP	Input	Over voltage protection input
4	RI	I/O	Set the switching frequency by external resistor
5	ENA	Input	On/off control signal input pin
6	CS	Input	Current sense input
7	GATE	Output	Gate drive output
8	VCC	I/O	Internal 10V LDO output
9	VIN	Power	Power supply
10	DMOD	I/O	In PWM to analog dimming, a capacitor is connected between the DMOD pin and GND; in direct PWM dimming, the DMOD is floating.
11	CMP	I/O	Loop compensation and soft start time setting
12	DIM	Input	PWM signal input pin for dimming control
13	LED2	I/O	LED string current input
14	LED3	I/O	LED string current input
15	GND	Power	Ground
16	LED4	I/O	LED string current input

Pin Configuration for OB3363TVP

```
        ┌──────────────────┐
LED1 ───┤ 1    ○       16  ├─── DIM
LED2 ───┤ 2            15  ├─── CMP
GND  ───┤ 3            14  ├─── DMOD
LED3 ───┤ 4   OB3363T  13  ├─── VIN
LED4 ───┤ 5            12  ├─── VCC
ISET ───┤ 6            11  ├─── GATE
OVP  ───┤ 7            10  ├─── CS
RI   ───┤ 8            9   ├─── ENA
        └──────────────────┘
            TSSOP16/PP
```

Terminal Assignment for OB3363TVP

| Number	Pin Name	I/O	Pin Function
1	LED1	I/O	LED string current input
2	LED2	I/O	LED string current input
3	GND	Power	Ground
4	LED3	I/O	LED string current input
5	LED4	I/O	LED string current input
6	ISET	I/O	Set the output current of every channels by external resistor
7	OVP	Input	Over voltage protection input
8	RI	I/O	Set the switching frequency by external resistor
9	ENA	Input	On/off control signal input pin
10	CS	Input	Current sense input
11	GATE	Output	Gate drive output
12	VCC	I/O	Internal 10V LDO output
13	VIN	Power	Power supply
14	DMOD	I/O	In PWM to analog dimming, a capacitor is connected between the DMOD pin and GND; in direct PWM dimming, the DMOD is floating.
15	CMP	I/O	Loop compensation and soft start time setting
16	DIM	Input	PWM signal input pin for dimming control

Functional Block Diagram
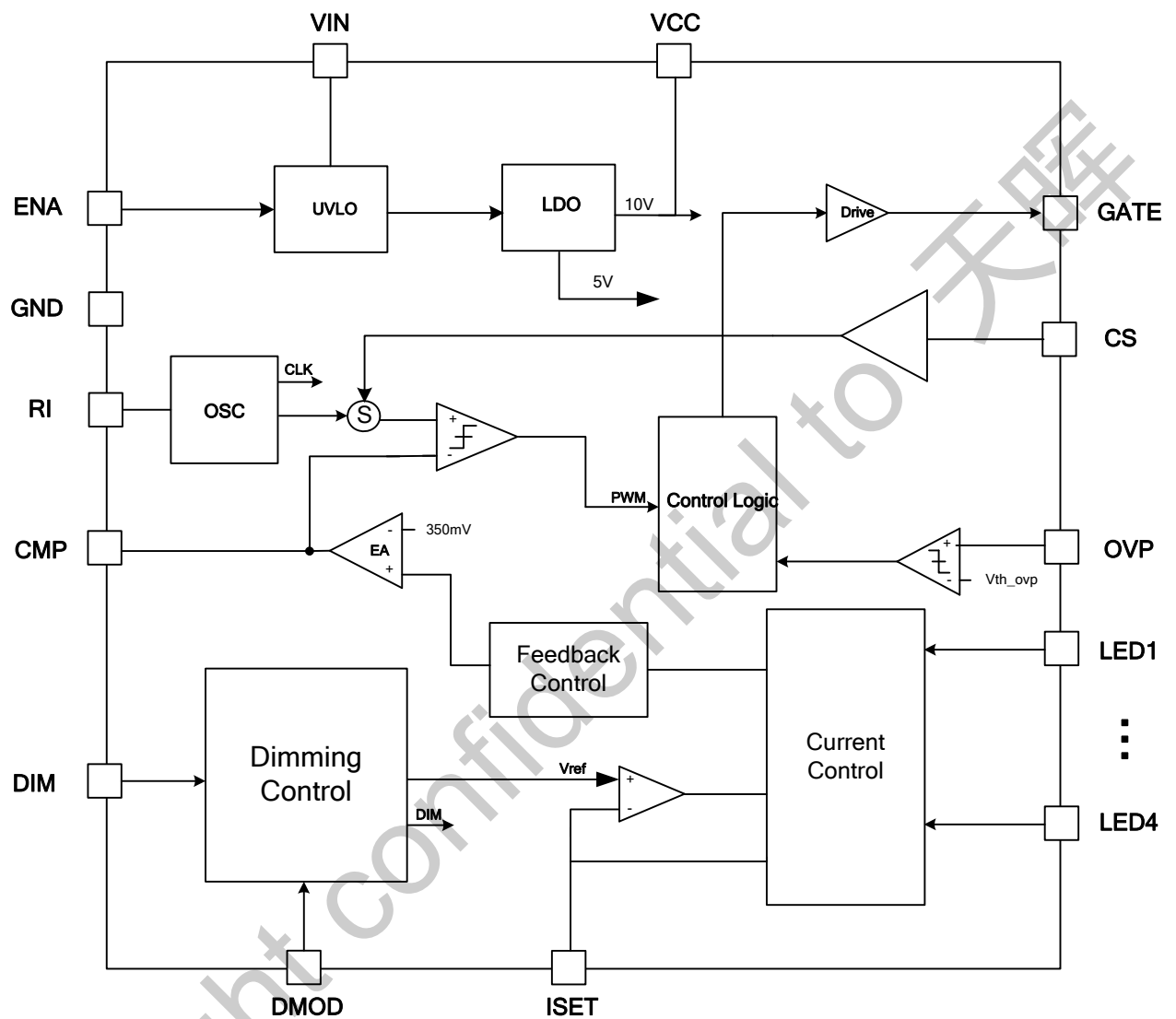
Figure2: OB3363T Functional Block Diagram

Electrical Characteristics

VIN=12V, ENA=5V, ISET=16kohm to ground, T_A=25℃, if not otherwise noted.

Parameter	Symbol	Condition	Min	Typ.	Max	Units
Operating Input Voltage	V_{IN}		6		40	V
Standby current	$I_{standby}$	ENA=0V			1	uA
Operating supply current	I_{VCC}	No switching, all LEDX floating		3		mA
LDO output Voltage	V_{CC}	V_{IN}> 11V	9.5	10	10.5	V
V_{IN} UVLO OFF	UVLO(OFF)			5.4		V
V_{IN} UVLO ON	UVLO(ON)			5.2		V
ENA High Voltage	V_{ENA_H}		2			V
ENA Low Voltage	V_{ENA_L}				0.8	V
Boost Converter						
OSC frequency	F_{OSC}	R_{RI}=374KΩ		170		KHz
Maximum Duty Cycle	D_{max}		90			%
Minimum On Time/LEB Time	T_{ON_MIN}/T_{LEB}			140		ns
CS Current Limit Voltage	$V_{limited}$			330		mV
Gate High Level	V_{H_GATE}			10		V
Gate Rising Time	T_{Rising}	C_{Load} = 2nF		70		ns
Gate Falling Time	$T_{Falling}$	C_{Load} = 2nF		50		ns
LED Current Regulation						
ISET Voltage	V_{ISET}			2		V
LEDX Current	I_{LED}	R_{ISET}=26.7kΩ		150		mA
Current Matching [1]					3	%
Current Matching [1]		Duty=10%,DMOD capacitor=0.1uF			10	%
LEDX Regulation Voltage	V_{LEDX}			350		mV
External LPWM Dimming Control						
External LPWM duty			0	-	100	%
External LPWM Logic input level	high		2.0			V
	low				0.8	V
PROTECTION						
OVP Over Voltage Threshold	V_{OVP_OV}	Rising Edge		2		V
OVP UVLO threshold (normal)	V_{OVP_UV}	System Startup		75		mV
		Normal operation		150		mV
LEDX Over Voltage Threshold	V_{LEDX_OV}			7.5		V
LED open protection threshold				200		mV
Thermal Shutdown threshold	T_{OTP}			165		℃
Thermal Shutdown Hysteresis				20		℃

Note: [1] *LEDX current includes matching rate.*
[2] *Matching is defined as the difference of the maximum to minimum current divided by two times of the average currents of all channels.*

$$\Delta = \frac{I_{LED\_MAX} - I_{LED\_MIN}}{2 \cdot I_{LED\_avg}} \times 100\%$$

Function Description

OB3363T white LED driver is designed for LCD backlight system applications. It incorporates a fixed frequency, current mode boost converter, a 10V regulator specially to power the gate driver, dimming control circuits and 4 channels current sources which regulate the current of LED array made up by 4 LED strings. When enabled, the converter boosts the output voltage to provide sufficient headroom for the current sources to regulate their respective string current. OB3363T features programmable operation frequency (from 100kHz to 600KHz) by setting the resistor on RI pin which allows the trade-off between the external components and the efficiency.

OB3363T offers comprehensive protection features to protect the system in various fault conditions. The open/short LED string protection ensures that one or more LED strings fail do not cause overall LED array out of function. The cycle-by-cycle current limit function limits the maximum current flowing through the external power MOSFET. The over temperature protection ensures that the system will not run into condition of thermal runaway and blow up.

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

Internal 10V Regulator VCC and UVLO

OB3363T includes an internal switching mode regulator which is specially used to power the gate driver. When the VIN is great than 10V, the regulator generates a 10V supply. If VIN smaller than 10V, the output of regulator can follow VIN voltage until VIN drop below the UVLO voltage threshold. The OB3363T also has an internal 5V regulator to power the rest analog and logic circuitry.

The OB3363T have Under Voltage Lockout (UVLO) function. The chip is disabled when the Vin is below the UVLO threshold (typical 5.2V) and the hysteresis of UVLO is nearly 200mV.

Fixed-Frequency Boost converter

A fixed-frequency, current mode, boost converter is built in and it automatically chooses the lowest active LEDX voltage to regulate the output voltage. The resulting error signal is amplified and compared to the internal 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.

OB3363T provides a gate driver which can provide 10V high level voltage (when VCC=10V), which greatly extends the selection range of external power MOSFET as well as increases the overall system efficiency.

At light loads, OB3363T automatically skips some pulses to improve efficiency and also prevent overcharging the output capacitor. In the pulse-skipping mode, the inductor current ramps up for a minimum on-time (typical 140ns), then deliver the stored energy to the output. The switch remains off until another pulse is needed to boost the output voltage.

LED Current Sources

Maintaining uniform LED brightness and dimming capability are critical for LCD backlighting applications. OB3363T is equipped with 4 matched current sources. These specialized current sources are accurate to within 3%. All LED full-scale currents are identical by setting through the resistor at ISET pin

$$I_{LED} = 2000 \times \frac{2.0V}{RSET}$$

The minimum voltage drop across each current source is approximately 350mV (typical). The low voltage drop helps to reduce the dissipation while maintaining sufficient compliance to control the LED current within the required tolerances.

If any one channel out of the total 4 channels is not used, the relative LEDX pin should be connected to a voltage that higher than 7.5V to disable this channel, the LEDX voltage must lower than 60V to prevent IC be damaged.

All LEDX pins in use are measured and the lowest voltage is extracted and fed into the step-up converter's error amplifier to regulate the step-up converter's output voltage.

Frequency Setting

The internal oscillator frequency is set by the resistor on at RI pin as shown in the equation. High frequency operation optimizes the regulator for small component size at the expense of efficiency due to increased switching losses. While low frequency operation offers the better overall efficiency, but requires larger components and more PCB area.

$$F_{OSC} = \frac{63580}{R_{RI}\,(k\Omega)}$$

Startup

When ENA is active high, OB3363T checks the topology connection first. The chip monitors the OVP pin to see if the Schottky diode is connected or the boost output is short to GND, if the voltage at OVP pin is lower than 75mV (typical), the output will be disabled. OB3363T 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.

Dimming Control
OB3363T offers both PWM dimming mode and PWM to analog dimming mode by the configuration of DMOD pin: if the DMOD is floating, then OB3363T works in directly PWM dimming mode. The chip accepts an external PWM signal at DIM pin with a swing voltage of 0V to a level greater than 2V. The LED brightness is controlled by the duty cycle of the external PWM signal. The burst frequency is equal to PWM frequency. If the DMOD is connected with a capacitor (usually greater 100nF) to GND, then OB3363T works in PWM to analog dimming mode. A square wave (low level 0V, high level 2V) whose duty cycle is the same as the duty cycle of the external PWM signal to DIM pin is filtered through an internal 50K resistor and capacitor on the DMOD pin to provide reference voltage to LEDX control blocks. The LEDX current in this mode is determined by:

$$I_{LED} = 2000 \times \frac{2.0V}{RSET} \times Duty$$

LED String Open Protection
The open LED string protection is achieved by OVP. When one or more strings are open, the respective LEDX pins are discharged to ground. Since the lowest LEDX is selected to be the input of the error amplifier of the boost converter, as a result, the output voltage will be charging until it exceeds OVP threshold. If the voltage level at the corresponding LEDX pin is less than 200mV (typical) while OVP happens, then the LED string open is recognized and the controller will mark off the open string. Once the mark-off operation completes, the remaining LED strings will force the output voltage back into tight regulation. The strings will keep the mark-off information until the system shuts down. The IC shuts down the boost converter if all strings in use are open.

LED String Short Protection
OB3363T will determine whether the short strings happened by monitoring the voltage level at LEDX pin. If one or more strings are shorted, the respective LEDX pins will be pulled up to the boost output and suffer high voltage stress. If the voltage on the LEDX pin exceeds the preset threshold level (7.5V, typically), then the string shorting condition is detected. Moreover, if this condition continues for greater than 8192 clock cycles, the respective string is marked off and its current regulation is disabled. Once the string is marked off, it is disconnected from the output voltage regulation loop of the boost converter. The marked-off strings will be shut down completely until the system restarts.

Diode/Inductor short protection
When the Schottky diode or the inductor shorts, the current of the power MOSFET increases significantly, which will result in the MOSFET permanent damage if the IC continuously works. OB3363T will monitor the voltage on CS pin voltage cycle by cycle, if the voltage on CS pin is greater than 1V (typical) for continuous 8 cycles. The IC will latch shutdown the gate output to prevent the MOSFET from permanent damage.

LEDX Short Protection
When one of LEDX is shorted to GND, the boost converter will continuously increase the output to OVP to try to mark off this LEDX channel by the LED open protection. But in some condition, if the output is power limited by OCP protection before the output reach the OVP voltage, the channel can never be turned off, in this case large current will go through both Schottky diode and MOSFET, and cause permanent damage. OB3363T will monitor the voltage on COMP pin, if the voltage on COMP pin is continuously greater than 2.5V (typical) for 100ms (when the switching frequency is 300 KHz). The IC will be latched off for the safe propose.

Thermal Shutdown
OB3363T includes a thermal protection circuit. When the junction temperature exceeds 165°C （typical), the controller and current sources shut down and do not restart until the junction temperature drops below 145°C (typical).
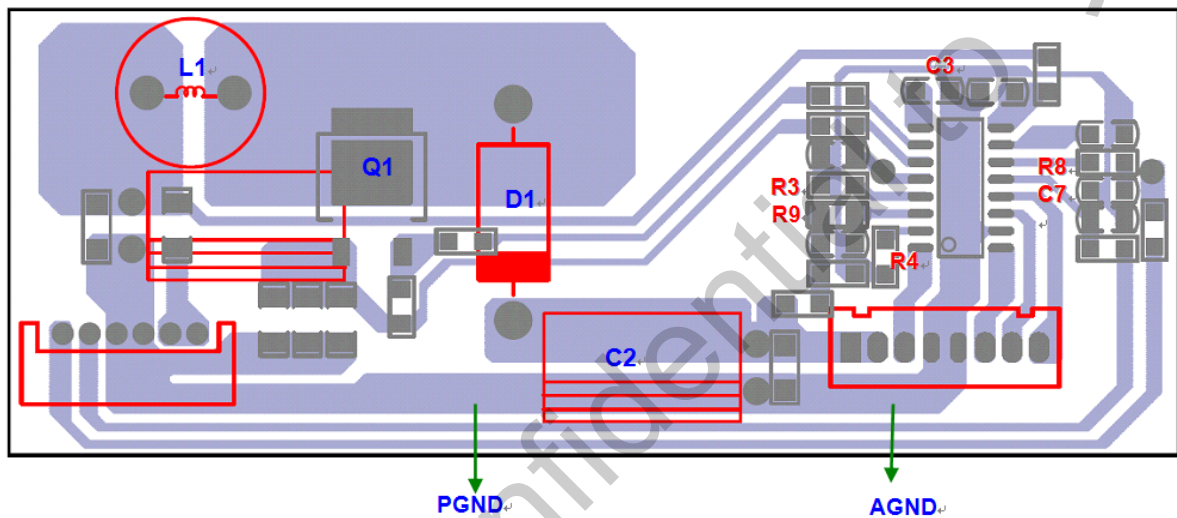
Layout Consideration

Careful attention must be paid to the PCB board layout and components placement. Proper layout of the high frequency switching path is critical to prevent noise and electromagnetic interference problems. Using the following guidelines for good PCB layout:

1) The loop of L1→D1→C2→GND and L1→Q1→GND is flowing with high frequency pulse current. It must be as small as possible; Use wide and short trace 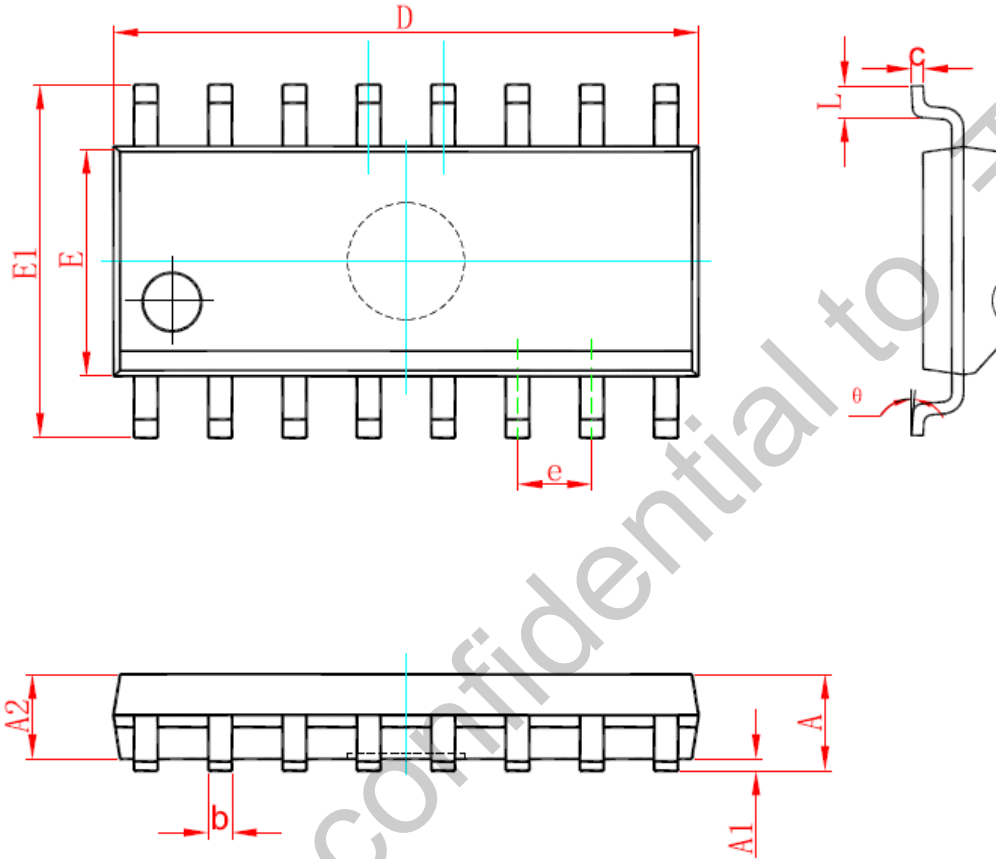for connecting the boost switching components（inductor (L1), external MOSFET (Q1), output diode (D1),and output capacitor(C2) ）.

2) Connect a separate signal ground trace to AGND pin, a separate power ground trace to PGND pin, In order to reduce LED ripple current, the AGND and PGND should be tied together at output capacitor GND.

3) Place the Vcc filter capacitor (C3), R3 (RI resistor), R8 (CMP resistor), C7 (CMP capacitor), R4 (ISET resistor) and R9 (limit current to OVP pin) as close to the IC as possible

Reference Application Circuit

Figure4：OB3363T Reference Application Schematic

VIN: 10-30V
DIM: LPWM Signal, Min. Brightness: 0%, Max. Brightness:100%
ENA: Disable, 0-0.8V; Enable, 2-5V
LOAD: I_{LED}/channel = 160 mA/channel, 10 LEDs/channel,

Package Mechanical Data:

SOP16 PACKAGE OUTLINE DIMENSIONS

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	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	9.800	10.400	0.386	0.409
E	3.800	4.040	0.150	0.159
E1	5.800	6.240	0.228	0.246
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

16-Pin Plastic ESOP (ESOP16)
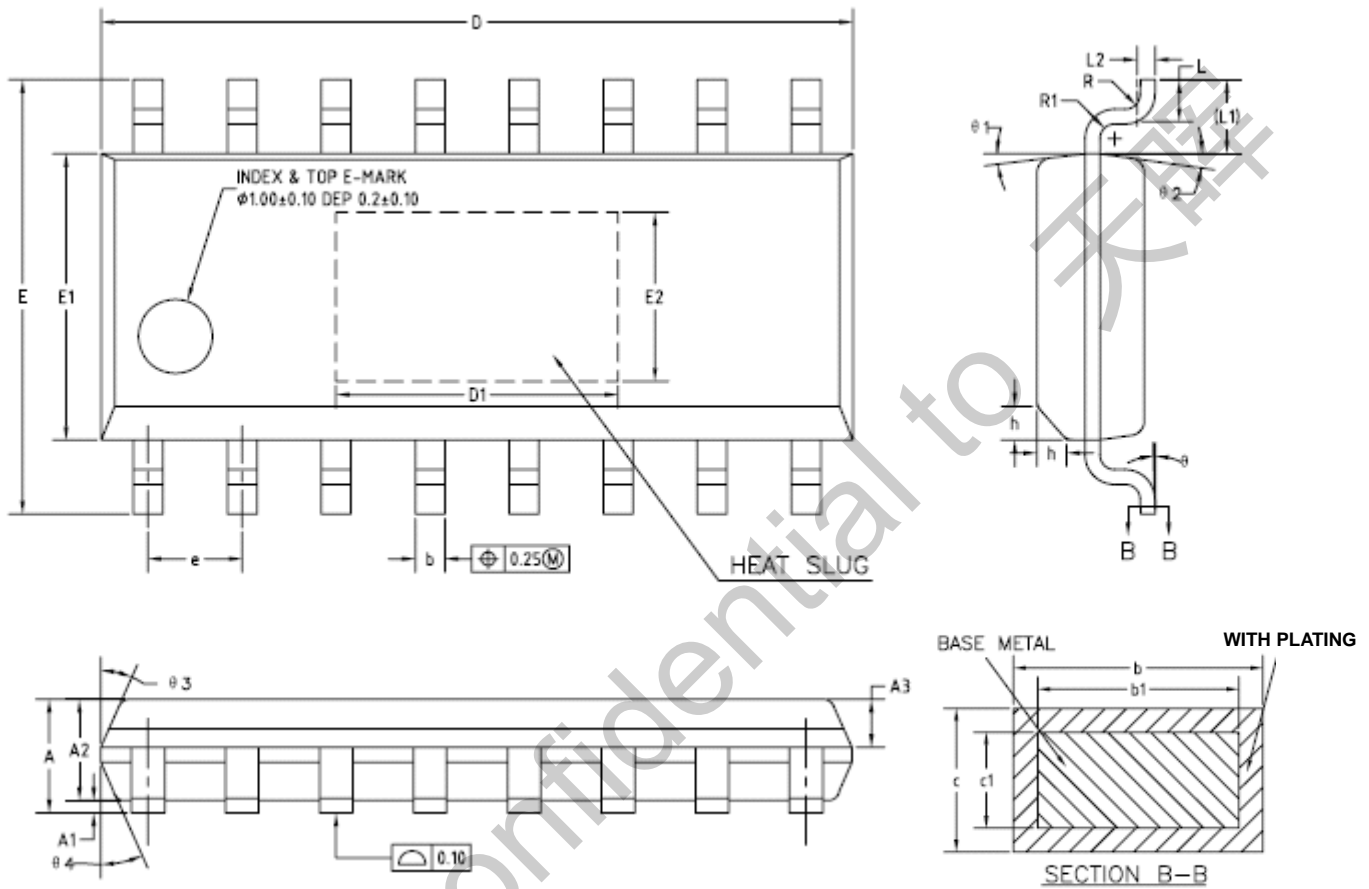
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.35	1.70	0.053	0.067
A1	0.02	0.12	0.001	0.005
A2	1.35	1.55	0.053	0.061
b	0.38	0.47	0.015	0.019
c	0.20	0.25	0.008	0.010
D	9.86	10.06	0.388	0.396
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27(BSC)		0.050(BSC)	
L	0.45	0.80	0.018	0.031
θ	0º	8º	0º	8º

16-Pin Plastic HTSSOP(HTSSOP16)
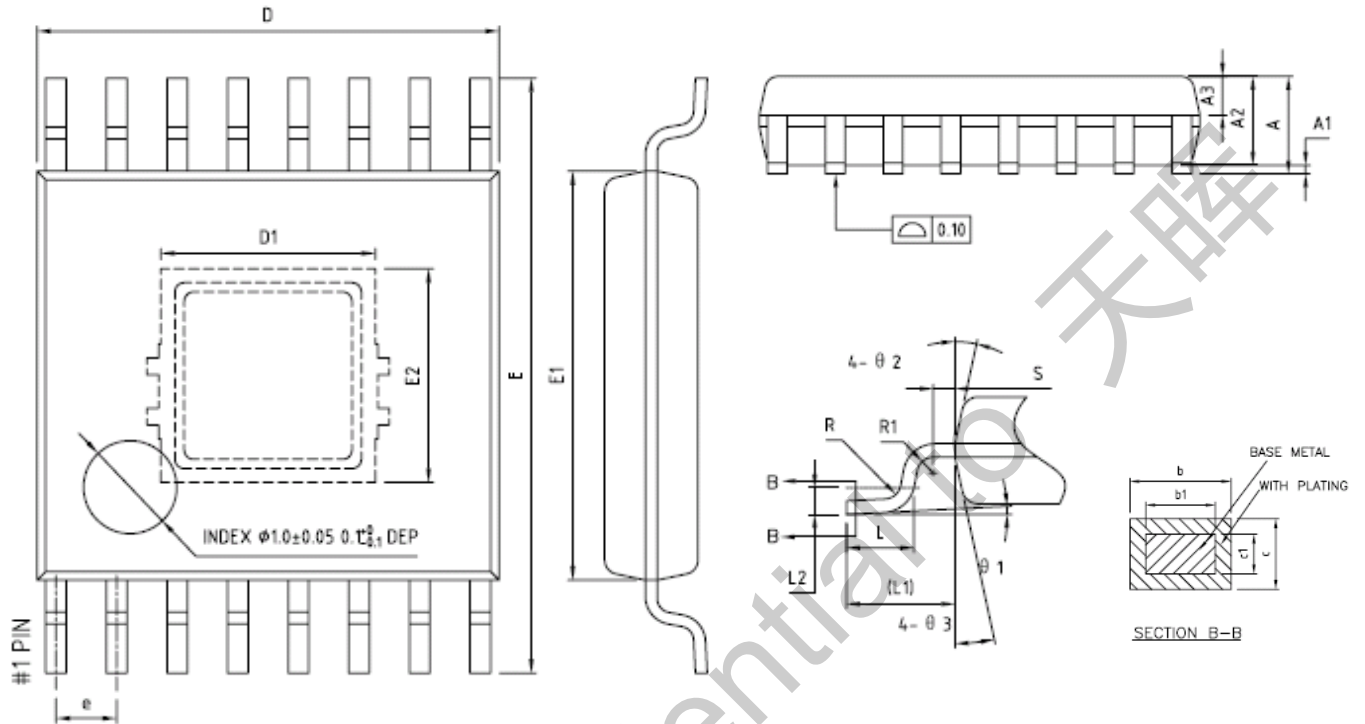
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
A	-	1.20	-	0.047
A1	0.05	0.15	0.002	0.006
A2	0.90	1.05	0.035	0.041
A3	0.34	0.54	0.013	0.021
b	0.20	0.29	0.008	0.011
c	0.13	0.18	0.005	0.007
D	4.86	5.06	0.191	0.199
D1	2.20	2.40	0.087	0.094
E	6.20	6.60	0.244	0.260
E1	4.30	4.50	0.169	0.177
E2	2.20	2.40	0.087	0.094
e	0.65(BSC)		0.256(BSC)	
L	0.45	0.75	0.018	0.030
θ1	0º	8º	0º	8º

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