GENERAL DESCRIPTION

The OB3362F 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 OB3362F 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 OB3362F integrates 4 channels current balancer with up to 200mA current capability per channel and it can achieve 3% matching accuracy among LED strings. The minimum voltage of current source is regulated to as lower as 350mV, which benefits the efficiency and improves the IC thermal performance.

The OB3362F supports external PWM dimming and internal burst dimming mode which allow flexible control of the backlight luminance. The LED current is directly modulated by external PWM duty cycle when PWM dimming mode is selected. The LED current can be adjusted by an external DC voltage when internal burst dimming mode is selected.

FEATURES

- 10V gate drive, better MOS compatibility
- High Efficiency and Compact Size
- 6V to 30V Input Voltage Range
- 3% Matching Accuracy Between 4 LED Strings Control Current
- 100KHz~600KHz Operating Frequency
- Internal/External PWM Dimming
- Very Low Standby Power
- Programmable Over Voltage Protection
- Under Voltage Lockout(UVLO)
- Open/Short LED Protection
- Thermal Shutdown

APPLICATIONS

- LCD Monitor
- LCD TV
- Flat panel display

OB3362F is offered in 16-pin ESOP/DIP

TYPICAL APPLICATION

Figure1: OB3362F Typical Application Schematic

Absolute Maximum Ratings

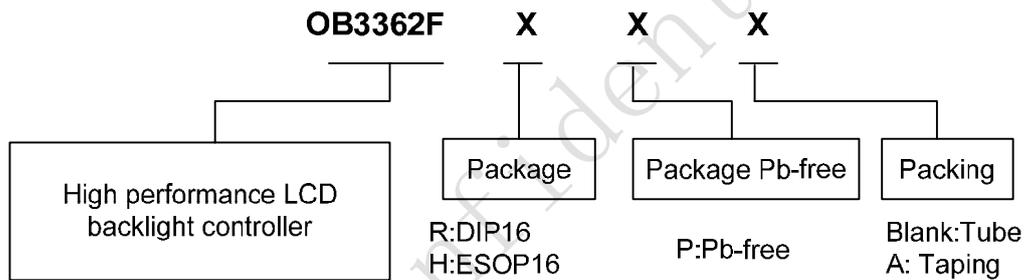| Parameter	Value
Vin Input Voltage to GND	-0.3V to 40V
FAULT to GND	Vin-7V to Vin
LEDX to GND	-0.3V to 40V
I/O to GND	-0.3V to 7V
Operating Ambient Temp. T_A	-20℃ ~ 85℃
Operating Junction Temp. T_J	150℃
Min/Max Storage Temp. T_{stg}	-55℃ ~150℃
Lead Temp. (10 Sec)	260 ℃

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 30V
Operating Frequency	100KHz to 600KHz

Ordering Information

Part Number	Description
OB3362FRP	DIP16, Pb-free in Tube
OB3362FHP	ESOP16, Pb-free in Tube
OB3362FHPA	ESOP16, Pb-free in T&R

OB3362F X X X

High performance LCD backlight controller

Package
R:DIP16
H:ESOP16

Package Pb-free
P:Pb-free

Packing
Blank:Tube
A: Taping

Marking Information

YWWZZZ
OB3362RP
F
S

Y: Year Code
WW: Week Code (1-52)
ZZZ:Lot Code
R: DIP16 Package
P: Pb-free Package
S: Internal Code

YWWZZZ
OB3362HP
F
S

Y: Year Code
WW: Week Code (1-52)
ZZZ:Lot Code
H: ESOP16 Package
P: Pb-free Package
S: Internal Code

Pin Configuration for OB3362F

ESOP16 / DIP16

ENA 1, DIM 2, GND 3, RI 4, ISET 5, BF/DMOD 6, LED1 7, LED2 8 (left side)

CMP 16, VCC 15, VIN 14, GATE 13, CS 12, OVP 11, LED4 10, LED3 9 (right side)
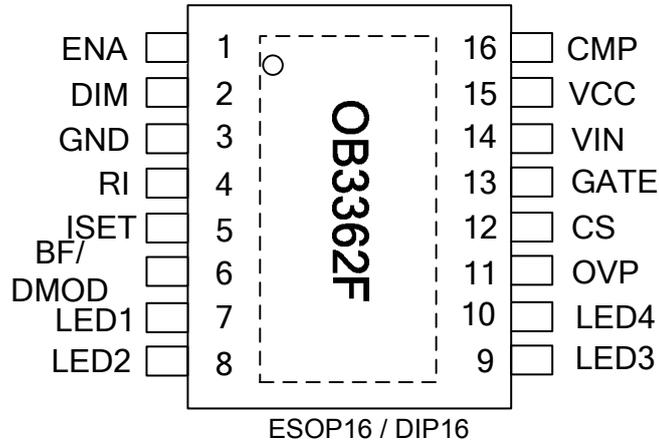
OB3362F

Terminal Assignment for OB3362F

Number	Pin Name	I/O	Pin Function
1	ENA	Input	On/off control signal input pin
2	DIM	Input	DC voltage or PWM signal input pin for dimming control, the DC voltage dimming is negative polarity
3	GND	Power	Ground
4	RI	I/O	Set the switching frequency by external resistor
5	ISET	I/O	Set the output current of every channels by external resistor
6	BF/DMOD	I/O	Dimming mode selection pin • Internal bust dimming mode: connect an external capacitor to ground, and the bust frequency is set by the capacitance • External PWM dimming mode: short this pin to ground.
7	LED1	I/O	LED string current input
8	LED2	I/O	LED string current input
9	LED3	I/O	LED string current input
10	LED4	I/O	LED string current input
11	OVP	Input	Over voltage protection input
12	CS	Input	Current sense input
13	GATE	Output	Gate drive output
14	VIN	Power	Power supply
15	VCC	I/O	Internal 10V LDO output
16	CMP	I/O	Loop compensation and soft start time setting

Functional Block Diagram
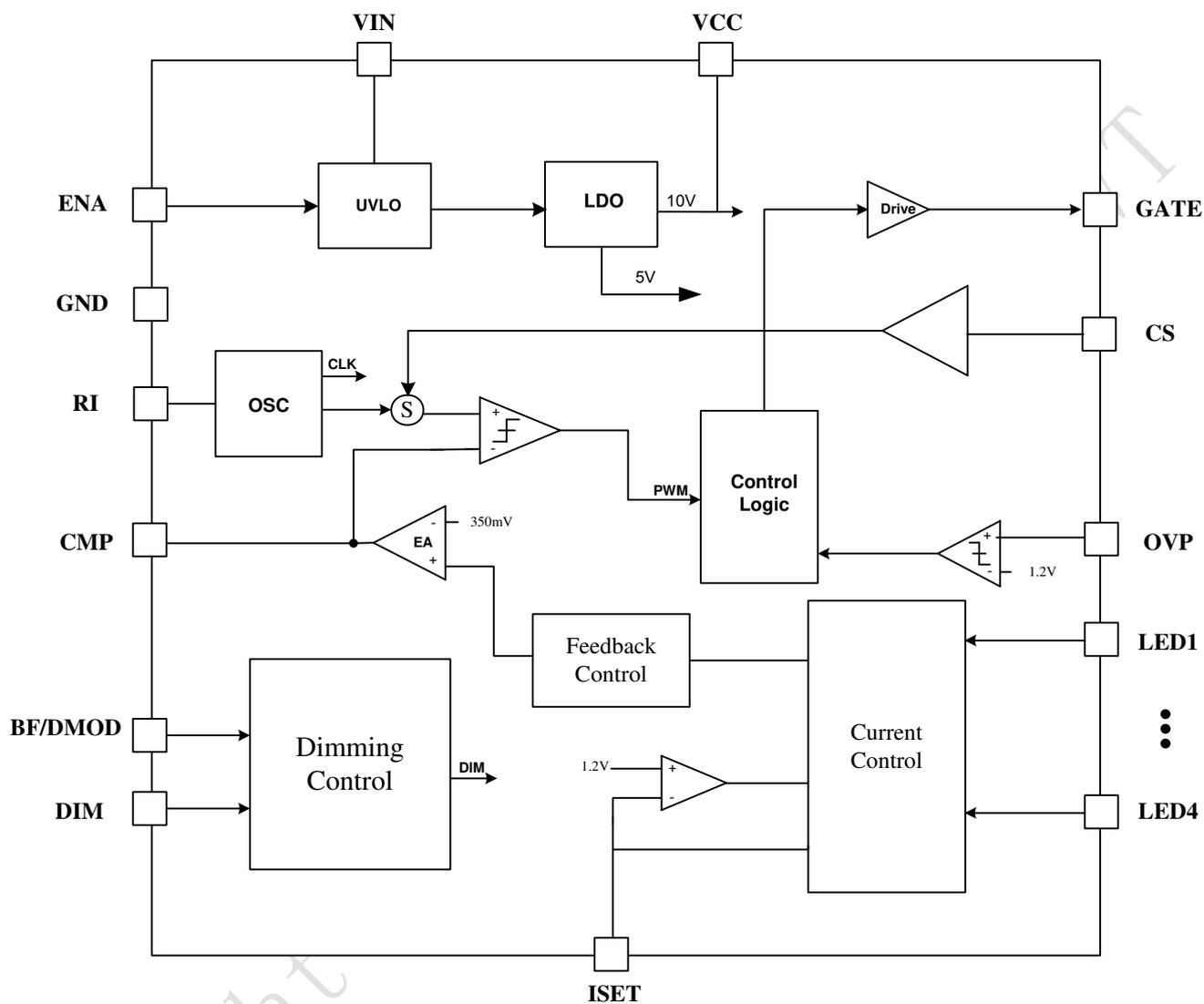
Figure2: OB3362F Functional Block Diagram

Electrical Characteristics

VIN=12V, ENA=5V, ISET=60kohm to ground, T_A=25℃, if not otherwise noted.

Parameter	Symbol	Condition	Min	Typ.	Max	Units
Operating Input Voltage	V_{IN}		6		30	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}			1.5		V
ENA Low Voltage	V_{ENA_L}			0.96		V
Boost Converter						
OSC frequency	F_{OSC}	R_{SET}=115K ohm		570		KHz
		R_{SET}=374K ohm		170		
OSC Voltage	V_{OSC}			1.25		V
Maximum Duty Cycle	D_{max}		90			%
Minimum On Time/LEB Time	T_{ON_MIN}/T_{LEB}			140		ns
CS Current Limit Voltage	$V_{limited}$		170	220	270	mV
Gate High Level	V_{H_GATE}			10		V
Gate Rising Time	T_{Rising}	C_{Load} = 2nF		40		nS
Gate Falling Time	$T_{Falling}$	C_{Load} = 2nF		20		nS
LED Current Regulation						
ISET Voltage	V_{ISET}			1.2		V
LEDX Current	I_{LED}	RSET=20k ohm		180		mA
Current Matching [1]		I_{LED} = 90mA	-		3	%
LEDX Regulation Voltage	V_{LEDX}			350		mV
Low Frequency Oscillator for Burst Mode Dimming						
Burst frequency		$C_{BF/DMOD}$=2.2nF	1.2	1.6	2	KHz
Triangular waveform	high	$C_{BF/DMOD}$=2.2nF		2.2		V
	low	$C_{BF/DMOD}$=2.2nF	-	0.2	-	V
External LPWM Dimming Control						
External LPWM duty		BF/DMOD=0V	0	-	100	%
External LPWM Logic input level	high	BF/DMOD=0V	2.0			V
	low	BF/DMOD=0V			0.8	V

PROTECTION						
OVP Over Voltage Threshold	V_{OVP_OV}	Rising Edge		1.2		V
OVP UVLO threshold (normal)	V_{OVP_UV}	System Startup		75		mV
		Normal operation		200		mV
LEDX Over Voltage Threshold	V_{LEDX_OV}		5	5.5	6	V
LED open protection threshold				200		mV
Thermal Shutdown threshold	T_{OTP}			165		℃
Thermal Shutdown Hysteresis				20		℃
VFAULT Clamp voltage to V_{IN}	V_{FAULT}	VIN=12V, V_{IN}-V_{FAULT}		5.1		V
VFAULT pull down current	I_{FAULT}			60		uA

Note: [1] *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

General Operation

The OB3362F 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. OB3362F features programmable operation frequency (100KHz to 600KHz) by setting the resistor on RI pin which allows the trade-off between the external components and the efficiency.

Internal burst and external PWM dimming modes are provided to offer the flexible dimming control. OB3362F 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

The OB3362F 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 OB3362F also has an internal 5V regulator to power the rest analog and logic circuitry.

The OB3362F have Under Voltage Lockout (UVLO) function. The chip is disabled when the Vin is below the UVLO threshold (typically 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.

The OB3362F has a gate driver which can provide 10V high level voltage (when VCC=10V), this can greatly extend the select range of external power MOSFET as well as increase the overall system efficiency.

At light loads, the OB3362F 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. The OB3362F 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 (18mA < ILED < 200mA).

$$I_{LED} = 3000 \times \frac{1.2V}{RSET}$$

The minimum voltage drop across each current source is approximately 350mV. 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 5.5V to disable this channel, the LEDX voltage must lower than 40V 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.

$$F_{OSC} = \frac{67850}{R_{RI}(k\Omega)}$$

Startup

When ENA is active high, the OB3362F checks the topology connection first. The control signal at FAULT pin turns on the external PMOS slowly, 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 75mV, the output will be disabled and the external PMOS is turned off. The OB3362F 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

Two commonly used PWM dimming modes, internal burst mode dimming and external burst (PWM) dimming, are supported without any additional external components. Different dimming modes are selected by BF/DMOD pin. The LED brightness is determined by the control signal at DIM pin.

External PWM burst dimming mode is selected by shorting BF/DMOD pin to ground. OB3362F accepts an external PWM signal to DIM pin with a swing voltage of 0V to a level greater than 2.2V. The LED brightness is controlled by the duty cycle of the external PWM signal. The burst frequency is equal to PWM frequency.

Internal PWM burst mode dimming mode is obtained by connecting a capacitor from the BF/DMOD pin to ground. A low frequency triangular waveform generator is formed by the capacitor and internal circuit of the IC. Duty cycle so as to LED brightness is controlled by the analog signal at DIM pin. The burst mode dimming frequency F_{burst} is set by the following equation:

$$F_{burst} = \frac{3.5uF}{C_{BF\_DMOD}}(Hz)$$

A DC voltage ranging from 0.2V to 2.2V at DIM pin corresponds to a LED brightness of approximately 0% to 100%, as shown in Figure 3.

$$Duty = \frac{(V_{DIM} - 0.2)}{2} \times 100\% \quad \text{for} \quad 0.2V \le V_{DIM} \le 2.2V$$

Table 2. Dimming mode selection

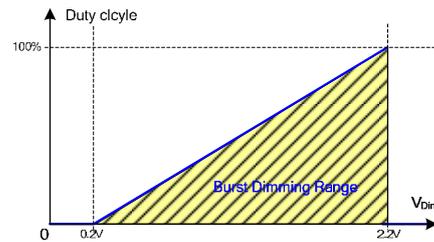| Function	Pin Connection		Polarity
	BF/DMOD	**DIM**	
Internal Burst	Capacitor	0.2V-2.2V	Positive
External LPWM	<0.1V	PWM	Positive

Figure3: Duty cycle of positive internal burst vs DIM voltage

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 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

The OB3362F will determine if 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 (5.5V), 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.

Thermal Shutdown

The OB3362F 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).
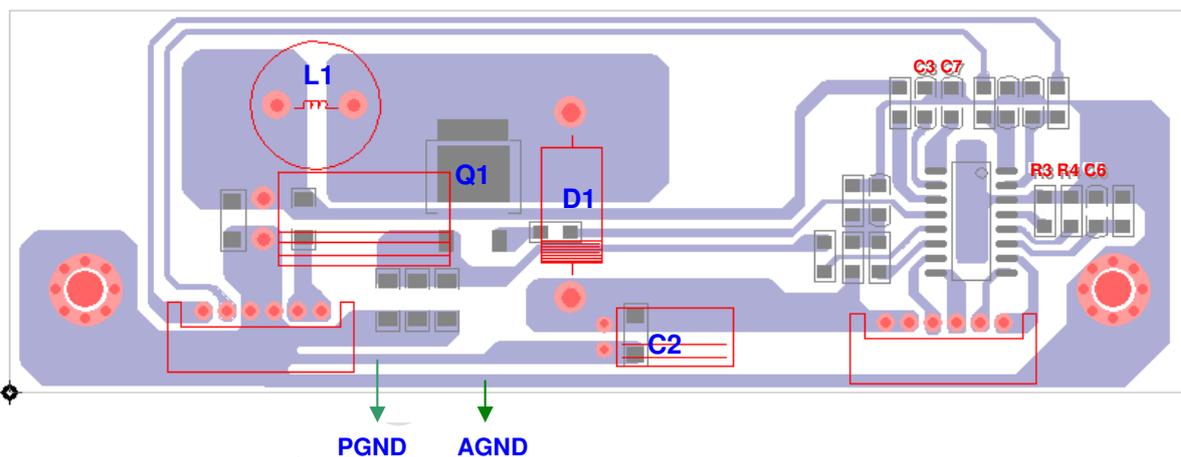
Layout Consideration

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) ）.
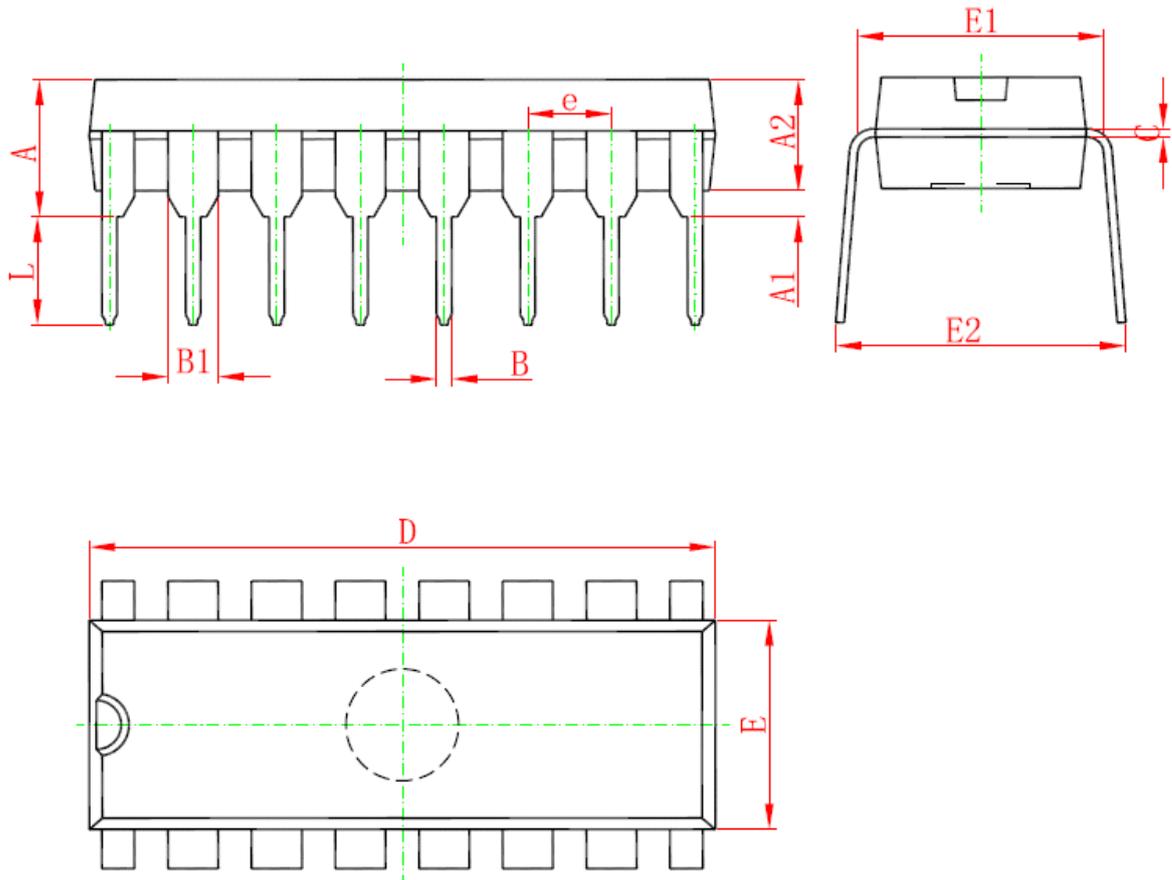
2) Connect a separate signal ground trace to AGND pin, a separate power ground trace to PGND pin, and then tie them together at input GND pin.

3) Place the Vcc filter capacitor (C3), R3 (RI resistor), C7 (CMP capacitor), C6 (BF/DMOD capacitor), and R4 (ISET resistor) as close to the IC as possible

4) The IC(ESOP16) exposed pad is internally connected to AGND pin ,OB3362F have a good thermal path to ambient to dissipate heat by connecting this pad to AGND trace


PGND   AGND

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Brighten Your Life

Reference Application Circuit

VIN: 10-30V
DIM: 0V, Max. Brightness; 5V, Min. Brightness (for internal burst mode dimming)
ENA: Disable, 0-0.8V; Enable, 2-5V
LOAD: I_{LED}/channel = 180 mA/channel, 10 LEDs/channel,

Figure4：*OB3362F Reference Application Schematic*

Package Mechanical Data:

DIP16 PACKAGE OUTLINE DIMENSIONS

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	5.334	0.146	0.210(0.181)
A1	0.381		0.015(0.020)	
A2	2.921	4.953	0.115	0.195(0.150)
B	0.380	0.570	0.015	0.022
B1	1.524 (BSC)		0.060 (BSC)	
C	0.200	0.360	0.008	0.014
D	18.800	20.230	0.740	0.800
E	6.096	7.112	0.240	0.280
E1	7.320	8.255	0.288	0.312
e	2.540 (BSC)		0.100 (BSC)	
L	2.920	3.810	0.115	0.150
E2	7.620	10.922	0.300	0.430

5.1.10 16-Pin Plastic ESOP
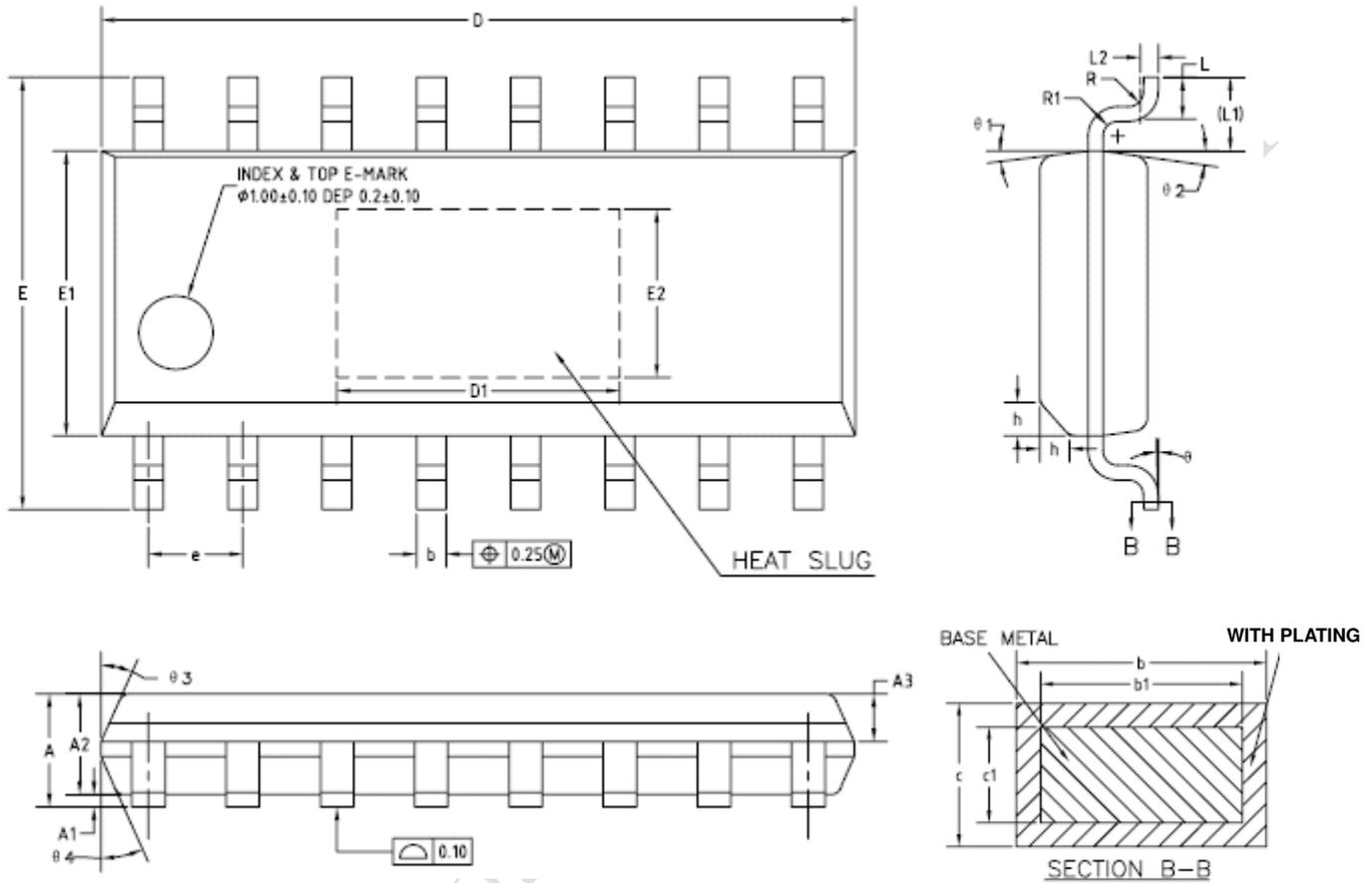
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	**Max**	**Min**	**Max**
A	1.35	1.70	0.053	0.067
A1	0.02	0.12	0.001	0.005
A2	1.35	1.55	0.053	0.061
b	0.38	0.47	0.015	0.019
c	0.20	0.25	0.008	0.010
D	9.86	10.06	0.388	0.396
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27(BSC)		0.050(BSC)	
L	0.45	0.80	0.018	0.031
θ	0º	8º	0º	8º

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