General Description

The OB3328 is a unique, high-efficiency and high-precision Cold Cathode Fluorescent Lamp (CCFL) backlight co ntroller IC d edicated to full bridg e configuration. The controller i s de signed to drive single or multiple CCF Ls in Liquid Crystal Display (LCD) applications.

The OB332 8 convert s unre gulated DC input voltage to the pure sin usoidal voltage and cu rrent waveforms i n requi red freque ncy, to ignite and operate CCFL lamps.

The OB332 8 provides a high deg ree of design flexibility by offering great program mability for key parameters which incl ude operating frequency, striking frequ ency, st riking time, bu rst dimming frequency, so ft-start time, and soft on/o ff time for burst dimming.

The OB332 8 offers variab le dimming mode s and selectable di mming pol arity[1]. Both internal burs t and externa l low frequ ency PWM (LPWM) dimming methods are available for a wide range of dimming control (10% to 100%). Fu rthermore, analog dimmi ng is provide d thro ugh external DC input control to achi eve 40% to 100 % dimmin g range.

The highly integrated OB3 328 provid es complet e protection fe atures covering IC un der voltage lockout (UVL O), output o ver voltage prote ction, and lamp fail safe function.

The OB33 28 is available i n DIP-16, S OP-16 a nd TSSOP-16 Packages.

Features

- Support wide input voltage
- Full bridge topology
- High precision reference and frequency control
- Built-in peak detect circuit reduces BOM count
- Support single or multi-lamp applications
- High flexibility of dimming configuration:
  Analog Dimming
  Internal/external burst (PWM) mode dimming
  Concurrent burst and analog dimming control
- Flexible user programmability:
  Operating frequency
  Striking frequency, striking voltage and time
  Soft start and soft on/off time
  Internal burst mode frequency
- Comprehensive protection coverage:
  IC supply under voltage lockout (UVLO)
  Output over voltage protection (OVP)
  Lamp fail safe function

Applications

- Notebook computer
- LCD Monitor
- LCD TV
- LCD flat panel display for Instrument, automobile and handhold device

[1] The OB3328 is with positive dimming polarity while its counter part OB3328N is in negative dimming polarity.

Typical Application Circuit

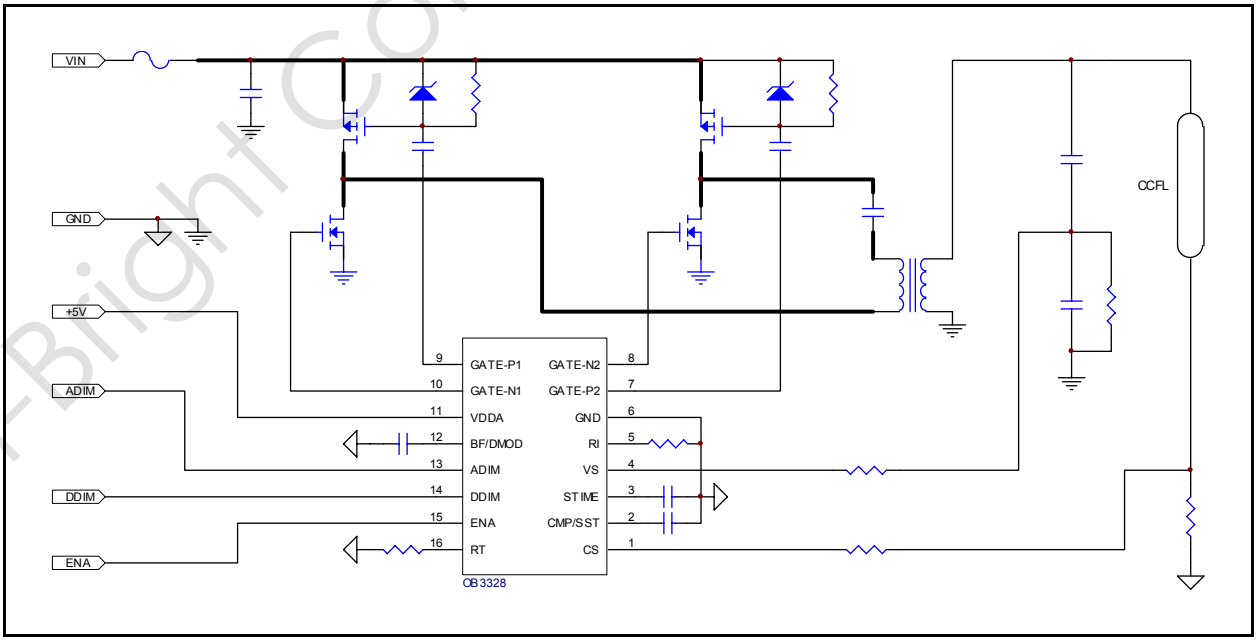


Figure1: OB3328 Typical Application Schematic

Absolute Maximum Ratings

Parameter	Value
VDDA Input Voltage to GND	7V
I/O to GND	-0.3 to VDDA + 0.3V
Operating Ambient Temperature T_A	-20 to 85°C
Operating Junction Temperature T_J	150°C
Min/Max Storage Temperature T_{stg}	-55 to 150°C
Lead Temperature (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
VDDA Voltage	4.5V to 5.5V
Operating Frequency	30 to 150KHz

Package Thermal Characteristics

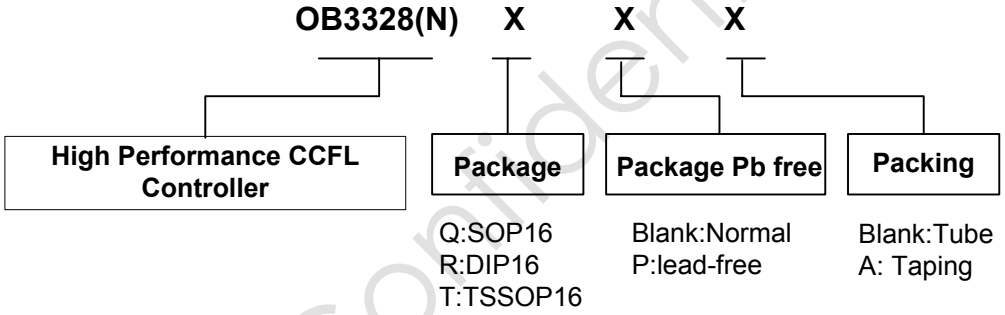
Parameter	Value
Thermal resistance θJA (SOP)	85 °C /W
Thermal resistance θJA (DIP)	60 °C /W

Ordering Information[2]

Part Number	Description
OB3328RP	DIP16, pb-free
OB3328QP	SOP16, pb-free
OB3328TP	TSSOP16, pb-free
OB3328NRP	DIP16, pb-free
OB3328NQP	SOP16, pb-free
OB3328NTP	TSSOP16, pb-free

[2] OB3328N is negative dimming version of OB3328.

Ordering information



Package Marking Information

SOP16

Y: Year Code (0-9)
WW: Week Code (1-52)
Q:SOP16
P:lead-free
s: internal code

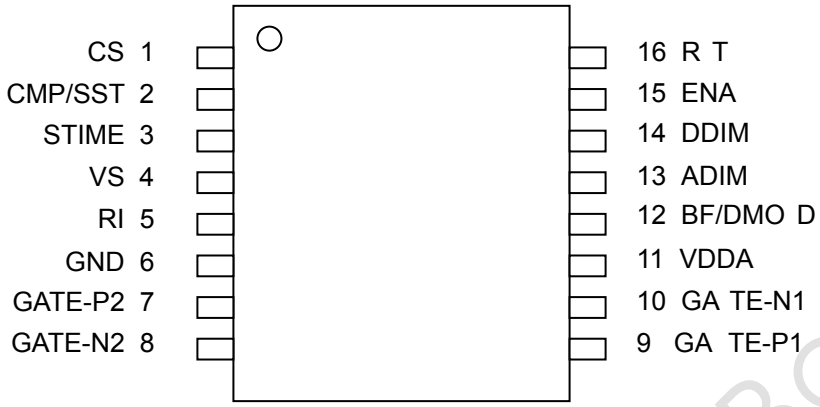
DIP16

Y: Year Code (0-9)
WW: Week Code (1-52)
R:DIP16
P:lead-free
s: internal code

TSSOP16

Y: Year Code (0-9)
WW: Week Code (1-52)
T:TSSOP16
P:lead-free
s: internal code

Pin Configuration



Terminal Assignment

Pin Number	Pin Name	I/O	Pin Function
1	CS	Input	Lamp current sense input
2 CMP/SST		I/O	Connected to Loop com pensation ca pacitor, this cap acitor also sets the soft start time
3	STIME	I/O	Connect to a capacitor to set striking time
4	VS	Input	Output voltage sense input
5	RI	I/O	Connected to resistor setting strike frequency
6 GND		Ground	Ground
7	GATE-P2	Output	P-MOSFET gate drive output2
8	GATE-N2	Output	N-MOSFET gate drive output2
9	GATE-P1	Output	P-MOSFET gate drive output1
10	GATE-N1	Output	N-MOSFET gate drive output1
11	VDDA	Power	+5V power supply
12 BF/DMOD		I/O	Connected to capacitor sets Burst frequency or connected to GND selects external LPWM mode dimming
13	ADIM	Input	DC signal input for analog mode dimming
14	DDIM	Input	Digital mode dimming control signal input
15	ENA	Input	Chip enable control input, active high
16	RT	I/O	Connected to an external resistor sets operating frequency

Functional Block Diagram

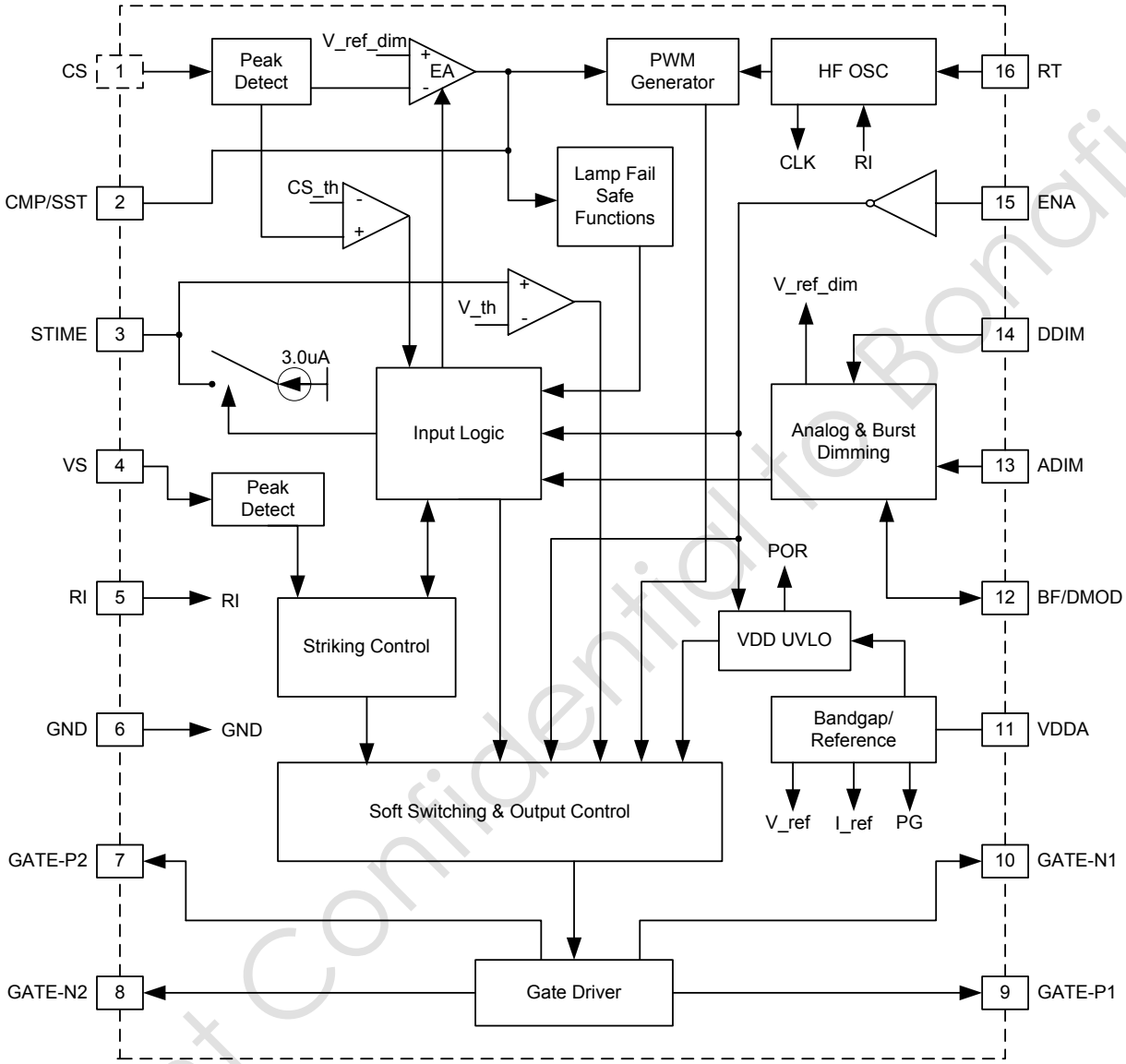


Figure2: OB3328 Functional Block Diagram

Electrical Characteristics

VDDA=5V, ENA=5V, RT=36Kohm, RI=107Kohm, ADIM=DDIM=5V, C_{BF}=10nF, C_{STIME} = 1uF, T_A=25°C if not otherwise noted.

Parameter Sy	mbol	Condition	Min	Typ	Max	Units
Current Consumption						
IC Standby	$I_{standby}$	ENA=0V	-	5	20	uA
Normal operating	I_{VDD}		-	4		mA
VDDA UVLO						
UVLO on			3.6			V
UVLO off			4.4			V
High Frequency Oscillator						
Operating frequency	F_{OP}		48	50	52	KHz
Striking frequency	F_{STK}		62	65	68	KHz
Temp. stability		TA = -20°C to 85°C	-	200	-	PPM/°C
Min. (overlap) duty cycle				1%		
Max. (overlap) duty cycle				45%		
Low Frequency Oscillator for Burst Mode Dimming						
Burst frequency			180	200	220	Hz
Temp. stability			-	400	-	PPM/°C
Min. burst duty	OB3328	DDIM =0V	-	10	-	%
	OB3328N	DDIM=0V		100		
Max. burst duty	OB3328	DDIM >3V	-	100	-	%
	OB3328N	DDIM>3.25		10		
Analog Dimming Control						
Min. CS reference Voltage	$V_{\_ref\_dim}$	ADIM= 0V	-	0.5	-	V
Max. CS reference Voltage	$V_{\_ref\_dim}$	ADIM> 3V	-	1.25	-	V
External LPWM Dimming Control						
External LPWM duty			10	-	100	%
External LPWM Logic input level	high		2.0			V
	low		0.8			V
Error Amplifier						
Reference voltage	V_{REF_PK}		1.2	1.25	1.3	V

Parameter Sy	mbol	Condition	Min	Typ	Max	Units
Open loop voltage gain				70	-	dB
Unity gain bandwidth		CMP=39nF		250		Hz
Supply Current						
Soft start current	I_{SST}			3.0		uA
Soft on/off current	I_{SOFT}			120		uA
Striking timer current	I_{STIME}		-	3.0	-	uA
Control and Protection Threshold						
Enable threshold	ON 0.8 OFF		 2.0			V
VS regulate voltage	VS_{PK} Whe	n striking		3.0		V
Over voltage protection	VS_{PK} Normal	Operating		3.0		V
Lamp fail safe protection	V_{CS_PK}			200		mV
Lamp fail safe deglitch time				20		mS
Striking timer threshold	V_{STIME}			3.0		V
Striking completion threshold	V_{CS_PK}			300		mV
Gate Driver Output						
GATE-N1/ GATE-N2	R_{ON}	I_{OUT}=70mA		8		ohm
GATE-P1/ GATE-P2	R_{ON}	I_{OUT}=70mA		8		ohm
Gate Driver Dead Time						
GATE-N1/GATE-P1		CMP=2V		400		nS
GATE-N2/GATE-P2		CMP=2V		400		nS

Function Description

High Efficiency Operation

The OB3328 CCFL controller is designed to drive the inverter system in full bridge topology, the resonant mode full bridge switches converts unregulated DC voltage to pure sinusoidal waveforms for CCFL operating with high efficiency and low EMI emission. The resonant frequency of the tank is set by the transformer leakage inductance, primary series capacitor and secondary parallel capacitor.

The OB3328 provides a high performance solution with a low system cost. One reference designs for single lamp application is shown in figure 3 on page 9.

Enable the Controller

OB3328 is activated by applying logic high to the ENA input. Control is TTL logic compatible. The controller is enabled when the voltage at ENA pin is higher than 1.1V. Toggling the ENA signal resets the state machine hence restarts the inverter system.

Lamp Ignition and Striking Voltage Regulation

A much higher voltage than that in normal operation is required to ignite CCFL, especially for aged lamp or in low ambiance temperature. The programmable striking frequency, voltage and ignition time set by RT, RI, VS, and STIME pins ensure sufficient voltage and time for any CCFL ignition. RI in paralleled with RT pin is used to set the oscillator frequency which is close to resonant frequency of the tank at ignition stage thus provide sufficient striking voltage. The output voltage is divided by the capacitive voltage divider (formed by C12 and C13 shown in figure 3 on page 9). The divided signal is fed into VS pin and its peak is compared with internal 3.0V threshold voltage. Consequently, the output voltage is regulated and limited. The striking voltage can be approximated as:

$$V_{striking} \approx \frac{3.0V \bullet C13}{\sqrt{2} \bullet C12}$$

Once the output voltage reaches the target level, and if CS pin voltage is less than 350mV, the IC will initiate the striking timer. An internal constant 3.0uA current source starts to charge the capacitor connected to STIME pin. Voltage higher than 3.0V at STIME pin indicates an ignition timeout. Under such circumstance, PWM Gate outputs are disabled and thus power switches are turned off. No energy is further delivered to the CCFL load.

Voltage at CS pin greater than 300mV indicates the lamp being ignited and capacitor at STIME pin will be discharged. Capacitor in appropriate value is required to provide sufficient time (typically, 1 second) to ignite the lamp. Ignition time is approximated as:

$$T(sec) = C[uF]$$

Over Voltage Protection

During normal operating, if VS peak voltage reaches the internal threshold of 3.0V, the controller immediately shuts down the inverter. OVP is a latch shutdown and could only be reset by toggling ENA pin.

Soft Start and Soft On/off

External capacitor connected to CMP/SST pin provides soft start and soft on/off control. At start up, an internal current source starts to charge the capacitor. Consequently, voltage at CMP/SST pin increases gradually and so as to the overlap time of the PWM Gate signals. This soft start control helps to reduce the MOSFET inrush current and voltage stresses, thus expand the lamp life. The slope of the soft start $\Delta V / \Delta T$ can be approximated as:

$$\frac{\Delta V}{\Delta T} = \frac{3 \times 10^{-6} \times 36}{C \times RT[kohm]}$$

Once lamps are ignited, the capacitor connected to CMP/SST pin performs the loop compensation function. In internal burst mode dimming or external burst (PWM) mode dimming conditions, the voltage ramping up and down at this pin performs a soft on/off control function in each burst cycle.

Normal Operation and Striking Frequency

The operation frequency is determined by the external resistor connected to RT pin. The operation frequency is calculated by the following equation:

$$F_{op}(KHz) = \frac{1800}{RT(Kohm)}$$

At ignition stage, RI pin is internally connected to RT pin, therefore external resistor at RI pin is in parallel with the external resistor at RT pin. The striking frequency can be calculated by the

following equation:

$$F_{striking}(KHz) = \frac{1751}{RI // RT(Kohm)}$$

Lamp Current Regulation

The lamp current is regulated by a lamp current feedback loop with an internal transconductance error amplifier, the AC lamp current is sensed by a sense resistor (R1 3 in figure 3 on page 9) connected in series with the low voltage terminal of CCFL lamp. The AC voltage across the sense resistor is fed into the CS pin. The peak voltage of sensed AC voltage is detected and compared with a 1.25V internal reference voltage. The error is amplified that controls the on time of the full bridge switches, as a result, the lamp current is regulated. the lamp current can be calculated by the following equation:

$$I_{lamp} = \frac{1.25V}{\sqrt{2} \bullet R_{sense}}$$

Lamp Fail Safe Functions

During normal operation, if the lamp is removed or damaged, the voltage at CS pin will drops to 0V. If the peak voltage at CS pin cannot be regulated to the predetermined value for more than 20ms, the inverter is latched shut down. Toggling ENA restarts the operation.

Dimming Control

Three commonly used dimming modes: analog mode dimming, internal burst mode dimming and external burst (PWM) dimming functions are supported without any additional components. The concurrent analog and burst achieves very wide dimming range.

DC voltage ranging from 0V to 3V at ADIM pin performs analog mode dimming control. The voltage at ADIM pin modulates internal error amplifier reference voltage from 0.5V to 1.25V, witch corresponds to a lamp current of approximately 40% to 100%.

The BF/DMOD pin is used for internal/external burst mode selection and internal burst frequency setting. External burst (PWM) dimming mode is selected by shorting BF/DMOD pin to ground. The OB3328 accepts an external low frequency PWM (LPWM) signal to DDIM pin with a voltage swinging from less than 0.8V to that of greater than 2.0V. The lamp brightness is controlled by the duty cycle of the LPWM signal. The burst frequency is equal to LPWM frequency.

Internal burst mode dimming is obtained by connecting a capacitor to BF/DMOD pin. A low frequency triangular waveform generator is formed by the capacitor along with internal comparator, internal current source and current sink. The triangular voltage waveform with peak of 3V and valley of 1V at this pin is used for the internal low frequency burst PWM generation. its duty cycle so as to lamp current is controlled by the DC voltage at DDIM pin. The burst frequency F_{burst} is set by the following equation:

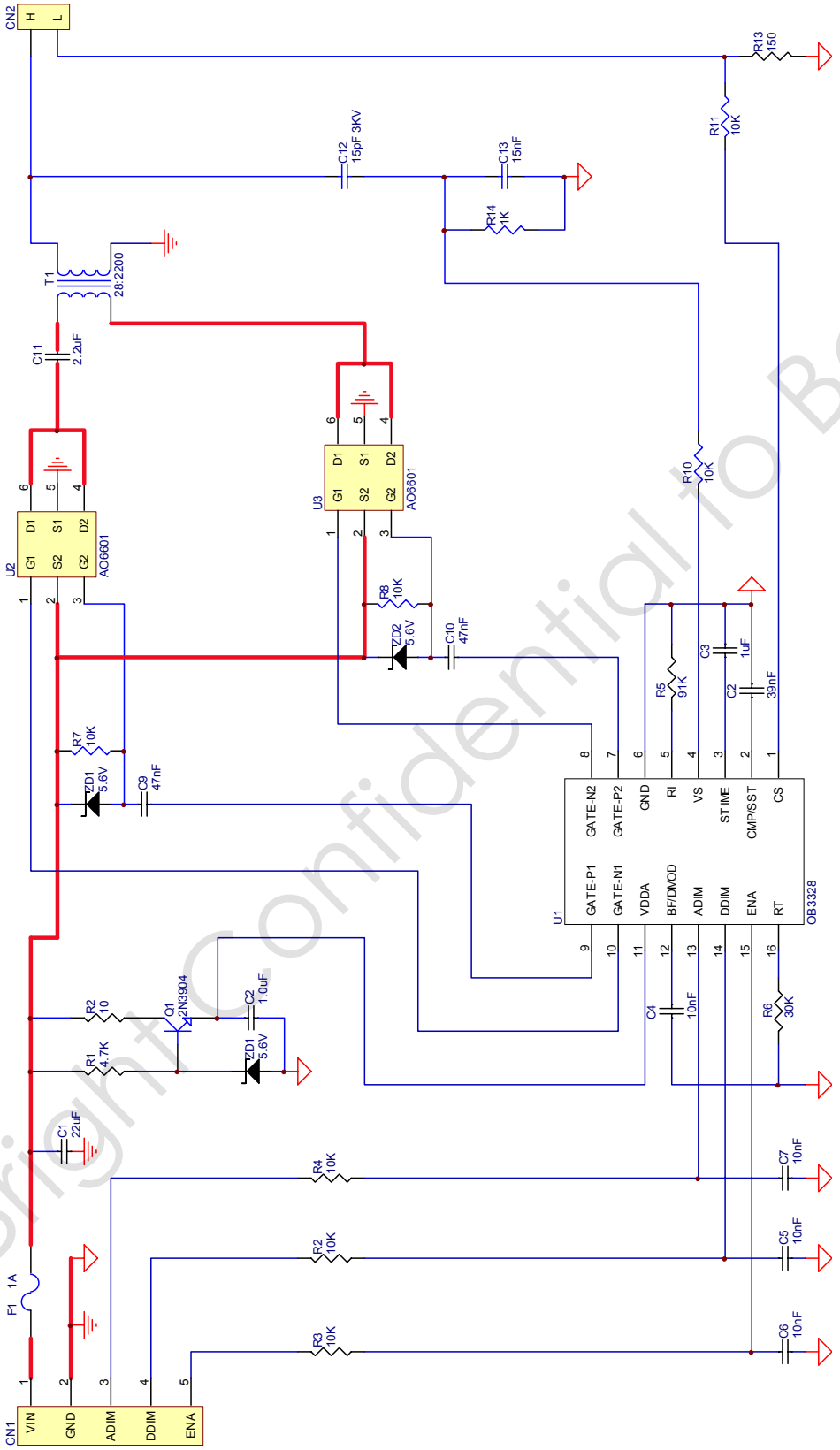
$$F_{burst}(Hz) = \frac{2000}{C_{BF}(nF)}$$

A DC voltage ranging from 0V to 3V at DIM pin corresponds to a lamp current of approximately 10% to 100%.

PIN\MODE	Analog	Internal Burst	External LPWM
BF/DMOD -		Capacitor	<0.5V
DDIM -		0-3V	External LPWM
ADIM 0-3V		-	-

The concurrent burst and analog dimming control can achieves approximately 4% to 100% dimming ratio.

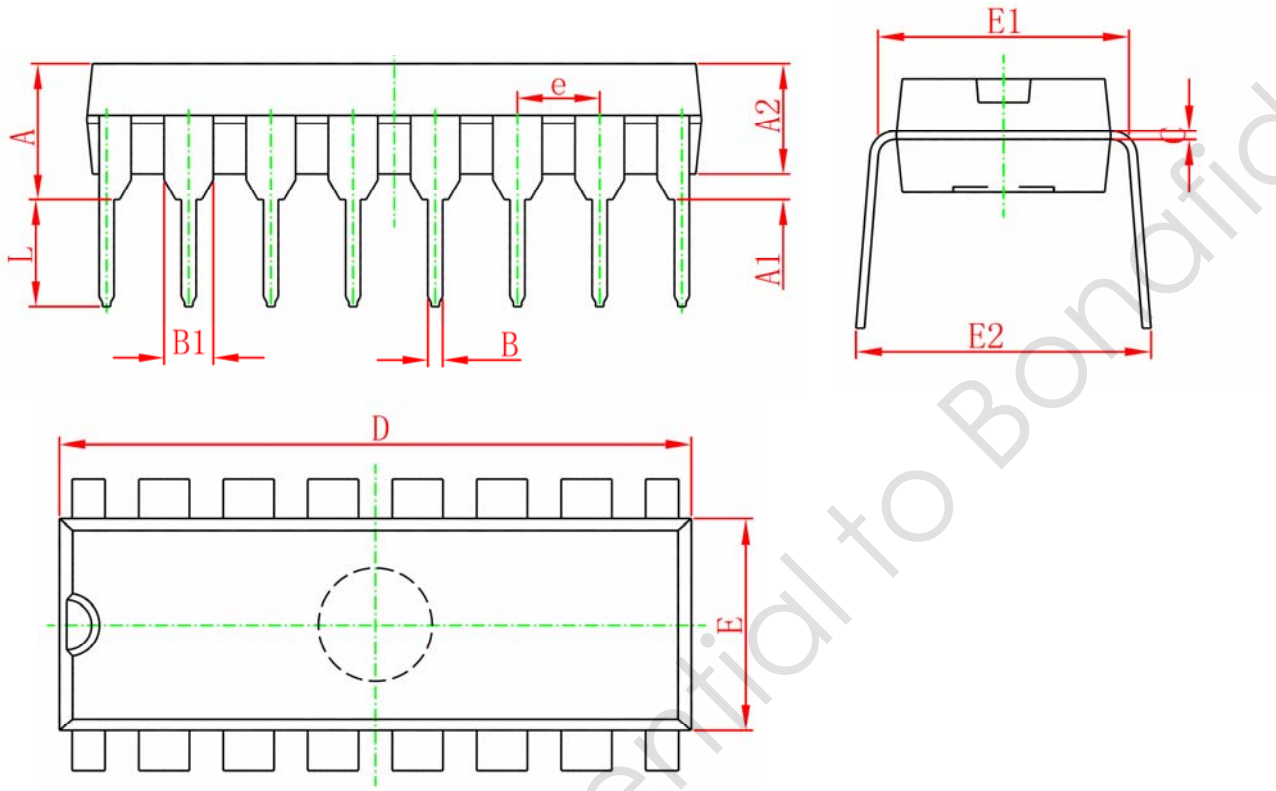
Reference Application Circuit for Single Lamp



VIN: 8~22V
ADIM: 3V, Max. Brightness; 0V, Min. Brightness (for analog mode dimming)
DDIM: 3V, Max. Brightness; 0V, Min. Brightness (for burst mode dimming)
ENA: Disable, 0-0.8V; Enable, 2-5V
LOAD: 82.5Kohm Dummy Load

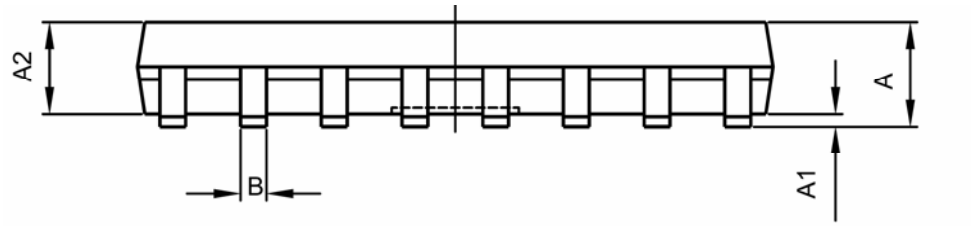
Figure3: OB3328 Reference Application Schematic

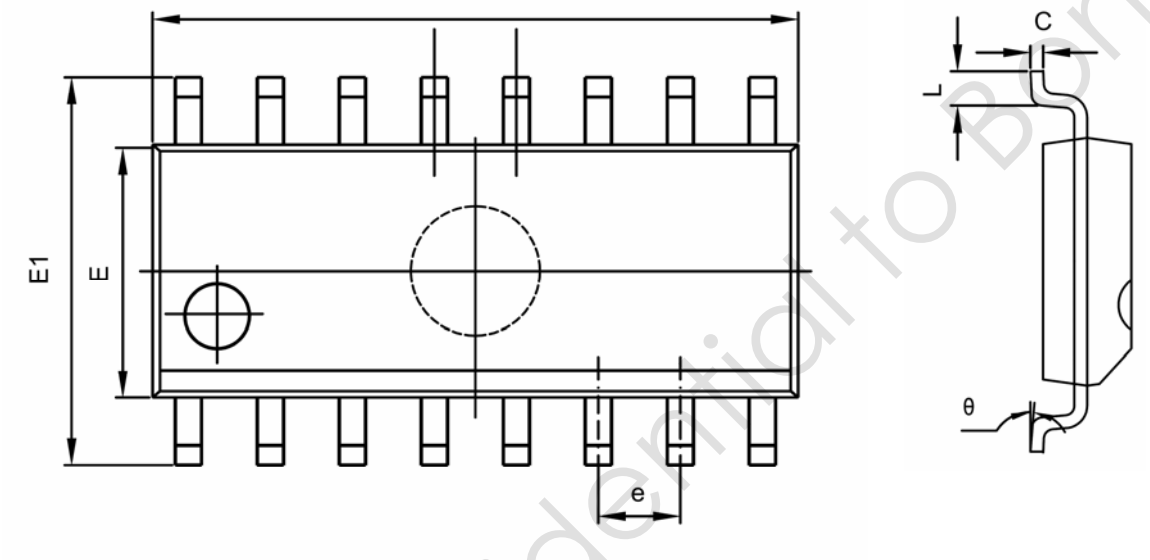
Package Mechanical Data: DIP16



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710 4.310		0.146	0.170
A1	0.510		0.020	
A2	3.200 3.600		0.126	0.142
B	0.380 0.570		0.015	0.022
B1	1.524 (BSC)		0.060 (BSC)	
C	0.204 0.360		0.008	0.014
D	18.800 19.200		0.740	0.756
E	6.200 6.600		0.244	0.260
E1	7.320 7.920		0.288	0.312
e	2.540 (BSC)		0.100 (BSC)	
L	3.000 3.600		0.118	0.142
E2	8.400 9.000		0.331	0.354

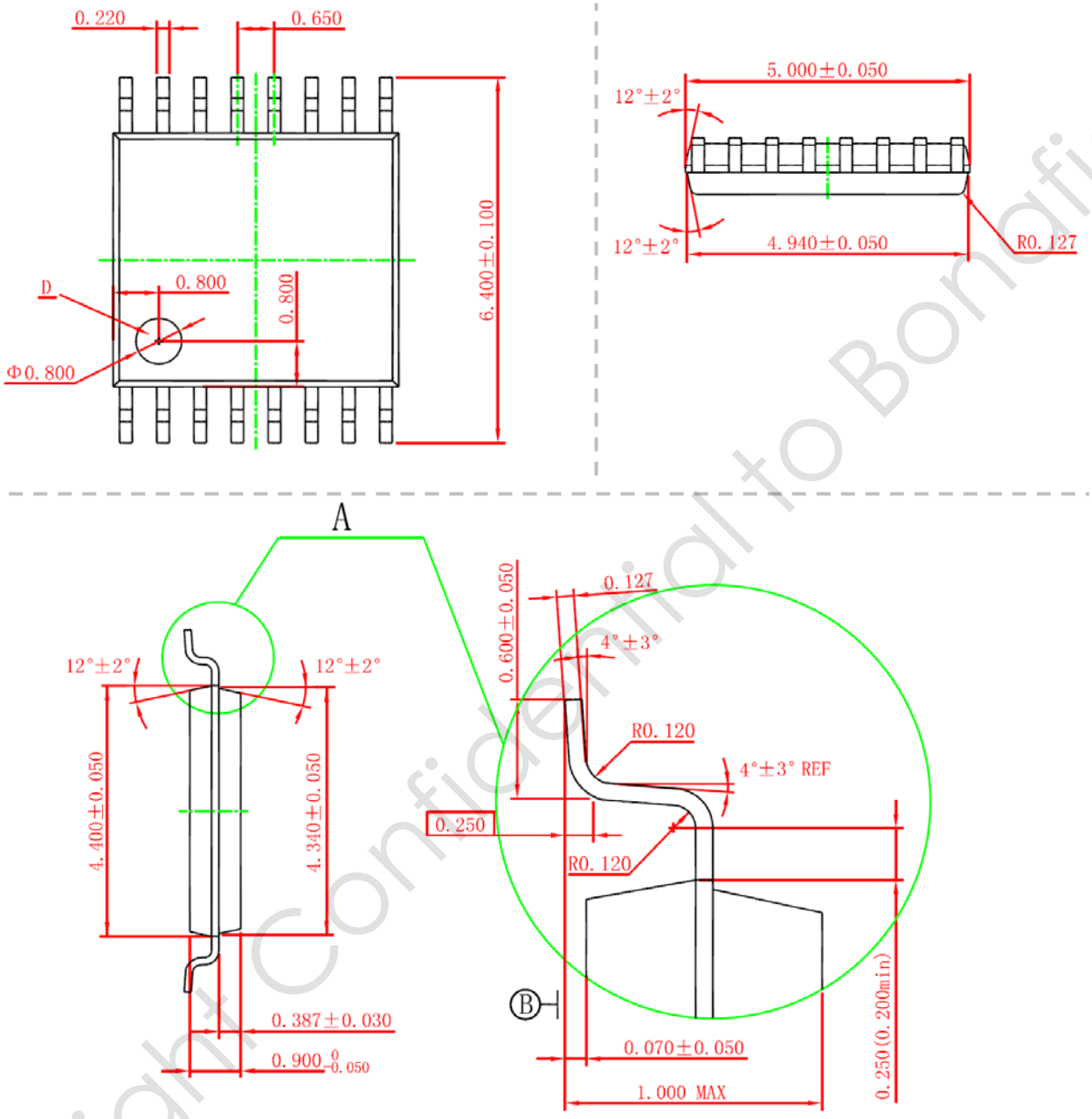
Package Mechanical Data: SOP16





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	1.350 1.550		0.053	0.061
B	0.330 0.510		0.013	0.020
C	0.190 0.250		0.007	0.010
D	9.800 10.000		0.386	0.394
E	3.800 4.000		0.150	0.157
E1	5.800 6.300		0.228	0.248
e	1.270 (TYP)		0.050 (TYP)	
L	0.400 1.270		0.016	0.050
θ	0°	8°	0°	8°

Package Mechanical Data: TSSOP16



The request of technology:

- Formed lead TIP planarity to datum plane B is ±0.025 Max;
- Package surfaces shall b e round su rface as Ra 0.800~1.200. Det ail “D” ro und su rface sho uld be polished finish, roughness as Ra 0.025~0.050 with depth 0.035 Max;
- General tolerance shall be ±0.050;
- All units are in millimeter;

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.