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General Description

OB3316 is a high performance Cold Cathode Fluorescent Lamp (CCFL) backlight controller IC dedicated for use in push pull configuration. The controller is designed to drive single or multiple CCFLs in Liquid Crystal Display (LCD) applications.

OB3316 converts unregulated DC input voltage to the pseudo sinusoidal voltage and current waveforms in required frequency, to ignite and operate CCFL lamps.
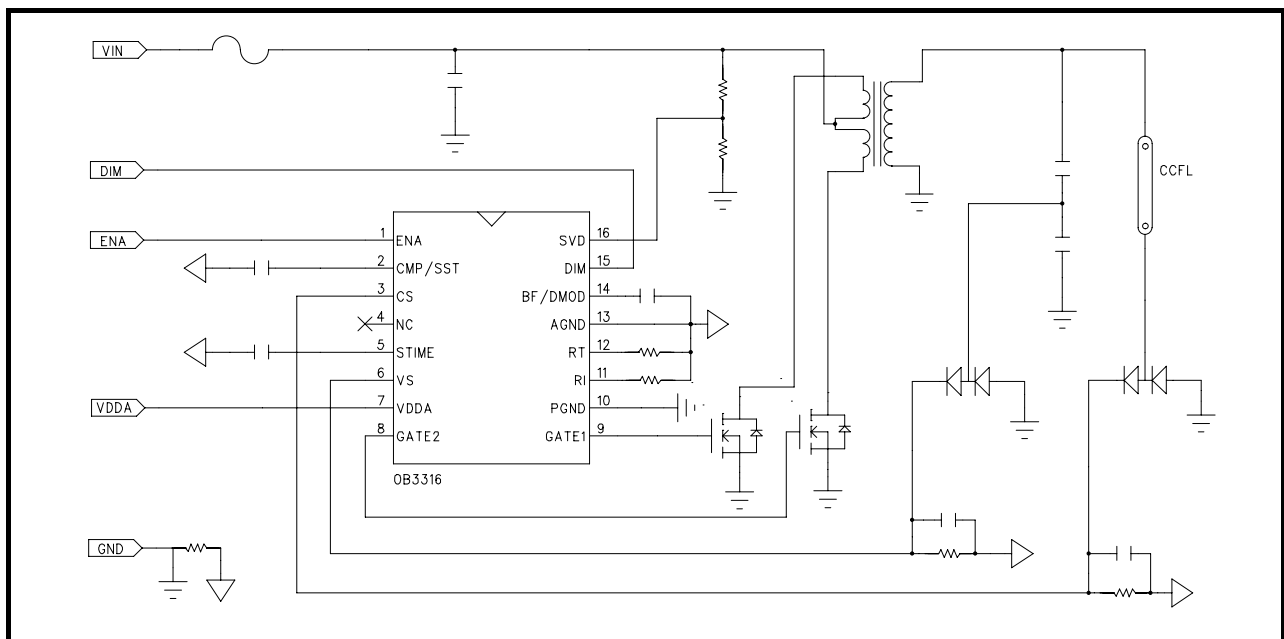
OB3316 provides a high degree of design flexibility by offering great programmability for key parameters which includes operating frequency, striking frequency, striking time, burst frequency for dimming and soft-start time.

OB3316 offers variable dimming controls. Both internal burst and external low frequency PWM (LPWM) dimming methods are available for a wide range of dimming control (10% to 100%). Further more, analog dimming is provided through external DC input control to achieve 40% to 100% dimming range.

The highly integrated OB3316 provides complete protection features covering IC Under Voltage Lockout (UVLO), System supply brownout protection, Output Over Voltage Protection (OVP) and Lamp Fail Safe Functions (LFSF).

OB3316 is available in DIP16 and SOP16 packages.

Features

- Built-in burst and external LPWM for wide range dimming control
- Analog dimming Control
- 0-3V DC voltage direct dimming without any additional components
- High precision reference and frequency control
- Support single or multiple CCFLs
- Flexible user programmability:
  External programmable constant operating frequency
  Programmable striking frequency and voltage control
  Programmable soft on/off timer
  Programmable striking time control
  Programmable internal burst mode frequency control
- Comprehensive protection coverage:
  IC supply under voltage lockout (UVLO)
  System supply brownout protection
  Output over voltage protection (OVP)
  Lamp Fail Safe Functions (LFSF)

Applications

- LCD Monitor
- LCD TV
- Notebook Computer
- LCD flat panel display for instrument, automobile and handhold device

Typical Application Circuit

Absolute Maximum Ratings

Parameter	Value
VDDA Input Voltage to AGND	7V
AGND to PGND	+/-0.3V
I/O(all pins except pin7, 10, 13) to AGND	-0.3 to VDDA + 0.3V
Operating Ambient Temperature T_A	0 to 70°C
Operating Junction Temperature T_J	150°C
Min/Max Storage Temperature T_{stg}	-55 to 150°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.
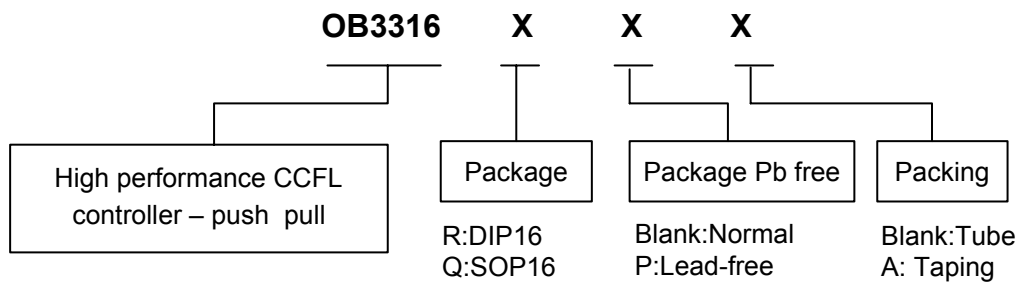
Recommended Operating Range

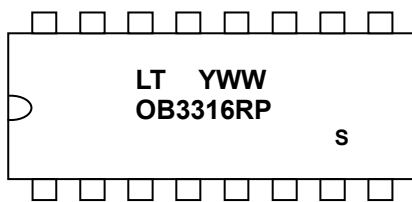| Parameter	Value
VDDA Voltage	4.5V to 5.5V
Operating Frequency	30 to 150KHz

Package Thermal Characteristics

Parameter	Value
Thermal resistance θJA (SOP)	85 ^{o}C /W
Thermal resistance θJA (DIP)	60 ^{o}C /W

Ordering Information

Part Number	Description
OB3316RP	DIP16, pb-free
OB3316QP	SOP16, pb-free

OB3316   X   X   X

High performance CCFL controller – push pull

Package
R:DIP16
Q:SOP16

Package Pb free
Blank:Normal
P:Lead-free

Packing
Blank:Tube
A: Taping

Package Marking Information
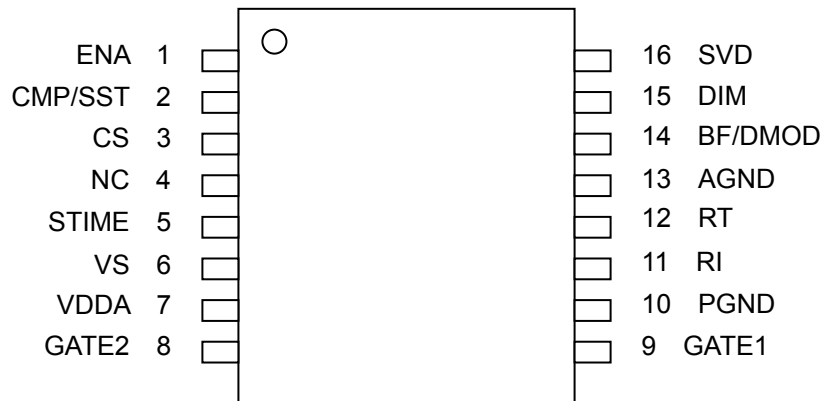
LT   YWW
OB3316RP
S

LT   YWW
OB3316QP
S

R: Package Designator for DIP16
P: Pb-free Package
Y: Year Code
WW: Week Code
S: Internal tracking Code

Q: Package Designator for SOP16
P: Pb-free Package
Y: Year Code
WW: Week Code
S: Internal tracking Code

Pin Configuration

```
ENA      1  ▭              ▭  16  SVD
CMP/SST  2  ▭              ▭  15  DIM
CS       3  ▭              ▭  14  BF/DMOD
NC       4  ▭              ▭  13  AGND
STIME    5  ▭              ▭  12  RT
VS       6  ▭              ▭  11  RI
VDDA     7  ▭              ▭  10  PGND
GATE2    8  ▭              ▭   9  GATE1
```

Terminal Assignment

Pin Number	Pin Name	I/O	Pin Function
1	ENA	Input	Active High. Enable Control Input
2	CMP/SST	I/O	Connected to Loop compensation capacitor, this capacitor also sets the soft start time
3	CS	Input	Lamp current sense input
4	NC	-	No Connection. Keep floating or short to ground in PCB
5	STIME	I/O	Connected to capacitor for striking time setting
6	VS	Input	Output voltage sense input
7	VDDA	Power	Power supply
8	GATE2	Output	N MOSFET drive output2
9	GATE1	Output	N MOSFET drive output1
10	PGND	Ground	Power ground
11	RI	I/O	Connected to Resistor setting strike frequency
12	RT	I/O	Connected to Resistor setting operating frequency
13	AGND	Ground	Analog ground
14	BF/DMOD	Input	Connected to Capacitor setting Burst frequency or used for dimming mode selection (Dual function input)
15	DIM	Input	Dimming control signal input
16	SVD	Input	System power supply voltage detect input

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Functional Block Diagram
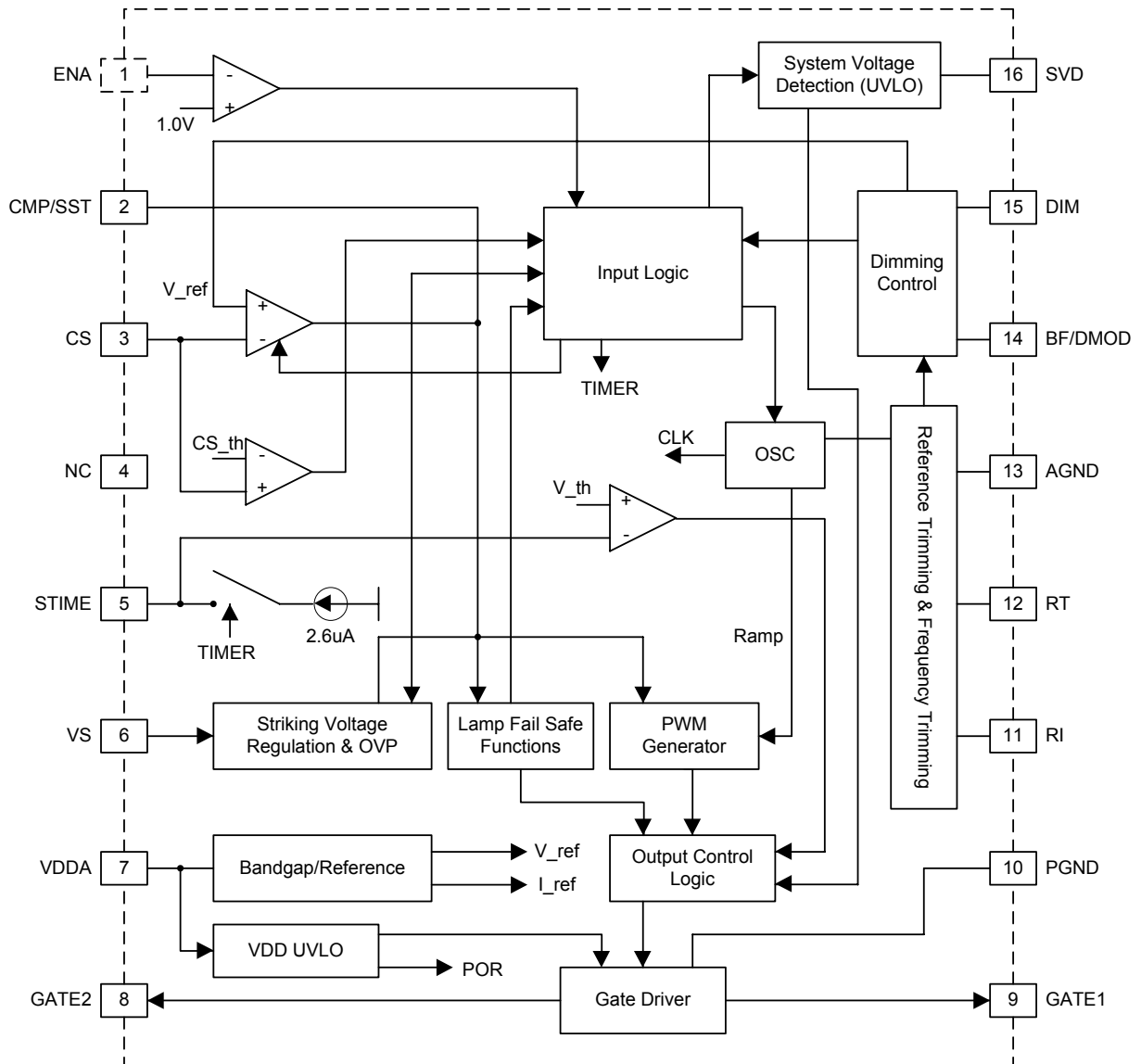
Electrical Characteristics

VDDA=5V, ENA=5V, SVD=5V, RT=33Kohm, RI=110Kohm, C_{CMP}=47nF, Dim=5V, C_{STIME} = 1uF, T_A=25°C if not otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Current Consumption						
Operating	I_{VDD}	VS=CS=1V, CMP=2V,	-	2.5	4	mA
VDDA UVLO						
UVLO on		Ramp VDDA form 5V to 0V		3.9		V
UVLO off		Ramp VDDA form 0V to 5V		4.1		V
High Frequency Oscillator						
Operating frequency	F_{OP}	CS=VS=1.25V, CMP=2V	48	50	52	KHz
Striking frequency	F_{STK}	VS=CS=0V, CMP=2V	-	65	-	KHz
Temp. stability		TA = 0 ^{o}C to 70 ^{o}C	-	200	-	PPM/ ^{o}C
PWM max. duty			-	45	-	%
Low Frequency Oscillator for Burst Mode Dimming						
Burst frequency		C_{BF}=10nF, DIM=1.5V	180	200	220	Hz
Temp. stability		TA = 0 ^{o}C to 70 ^{o}C	-	400	-	PPM/ ^{o}C
Min. burst duty		C_{BF}=10nF, DIM=0V	-	10	-	%
Max. burst duty		C_{BF}=10nF, DIM=3V	-	100	-	%
Analog Dimming Control						
Minimum Lamp Current reference Voltage		BF>3.5V, DIM=0V	0.45	0.5	0.55	V
Maximum Lamp Current reference Voltage		BF>3.5V, DIM=3V	1.2	1.25	1.3	V
External LPWM Dimming Control						
External LPWM duty		BF<0.5V, DIM=LPWM	10	-	100	%
External LPWM Logic input level	high		2.0	-	-	V
	low		-	-	0.8	V
Error Amplifier						
Input voltage range			0	-	VDD-1.6	V

Reference voltage	V_{REF}		1.20	1.25	1.30	V
Open loop voltage gain			-	70	-	dB
Unity gain bandwidth		C_{CMP} = 47nF	-	250	-	Hz
Supply Current						
Soft start current	I_{SST}		-	3	-	uA
Striking timer current	I_{STIME}		-	2.6	-	uA
Control & Protection Threshold						
Enable threshold High	$V_{IH\_}ENA$		2.0			V
Enable threshold Low	$V_{IL\_}ENA$				0.8	V
Lamp fail safe functions CS threshold	V_{TH_OL}			300		mV
Lamp fail safe functions CS deglitch time	$T_{\_OL}$			20		mSec
Ignition completion CS threshold	V_{TH_IGC}			350		mV
System under voltage threshold	V_{TH_SVD}		1.20	1.25	1.30	V
Striking timer threshold	V_{STIME}			2.6		V
VS regulate voltage at Strike	V_{TH_REG}	CS=0V		3.0		V
VS Over voltage threshold at normal operate	V_{TH_OV}	CS=1V		3.0		V
Gate driver output						
Gate1	R_{ON}	$I_{sink/Isource}$=70mA	-	8	12	ohm
Gate2	R_{ON}	$I_{sink/Isource}$=70mA	-	8	12	ohm

Function Description

High Efficiency Operation

OB3316 drives the push pull power train where transformer couples the energy from the power source to the secondary CCFL load. Two switches in the push pull topology are driven alternatively to convert the DC voltage to AC voltage. The resonant frequency of the tank is set by the leakage inductance and the output capacitance in secondary side. The resonant tank produces quasi-sinusoidal voltage and current waveforms for CCFL load with higher efficiency, lower EMI and heat dissipation that result in higher system reliability.

OB3316 provides a high performance solution with a low system cost. Referring to the schematic on page9, reference design for one lamp application is shown.

Enable the Controller

OB3316 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 1.0V. Toggling the ENA signal resets the state machine hence restarts the inverter.

Lamp Ignition

Voltage much higher than in normal operation is required to ignite CCFL, especially for aged lamp or in low ambiance temperature condition. The programmable striking frequency, voltage and ignition time set by RI, RT, VS, and STIME pins ensure sufficient voltage and time for any CCFL ignition. RI and RT are 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 and is further rectified. The rectified signal is fed into VS pin and compared with internal 3.0V threshold voltage. Consequently, the output voltage is regulated and limited.

Once the output voltage reaches the maximum level, an internal constant 2.6uA current source starts to charge the capacitor connected to STIME pin if voltage at CS pin is less than 350mV. Voltage at CS higher than 350mV indicates the lamp been ignited and trigger capacitor at STIME to discharge.

Voltage higher than 2.6V at STIME indicates an ignition timeout/failure. Under such circumstance, PWM Gate outputs are disabled and thus power switches are turned off. No energy is further transferred to the CCFL load. Capacitor in appropriate value is required to provide sufficient time (typical 1 second) to ignite the lamp.

Ignition time is approximated as:

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

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 duty cycle of the PWM Gate signal. This soft start control helps to reduce the MOSFET inrush current and voltage stresses, expand the lamp life. The slope of the soft start $\Delta V / \Delta T$ can be approximated as:

$$\frac{\Delta V}{\Delta T} = \frac{3 \times 10^{-6} \times 25.4}{C \times RI//RT[kohm]}$$

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

System Power Supply Under Voltage Lockout

OB3316 provides system power under voltage lockout function with SVD pin. The system power supply is divided by a resistive voltage divider and fed into SVD pin. It is compared with an internal threshold voltage of 1.25V. Once SVD voltage is lower than 1.25V, the controller stops the energy delivering to the CCFL load if it lasts a period larger than 20ms.

OB3316 automatically restarts the operation when the system power supply voltage goes back to the normal operation range.

Normal Operating and Striking Frequency

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

$$F_{op}(KHz) = \frac{1650}{RT(Kohm)}$$

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:

$$F_{striking}(KHz) = \frac{1650}{RI // RT(Kohm)}$$

Striking Control and Output Voltage Regulation

OB3316 provides output voltage regulation and clamping to protect the transformer from abnormal high voltage.

During start up, transformer output voltage signal is sensed by the capacitive voltage divider and rectified. The signal is brought into the controller through VS pin. When the voltage at VS pin reaches OVP threshold of 3.0V, a timer is activated by charging the external capacitor connected to STIME pin. Striking sequence starts and output voltage is regulated since VS input is clamped at 3.0V. If no lamp current is sensed after STIME voltage reaches 2.6V, the controller assumes striking failure and shuts down the output.

During normal operating, if VS voltage reaches 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.

Lamp Fail Safe Functions

During normal operation, if the lamp is removed or damaged, the voltage at CS pin drops to 0V. If CS Pin voltage is lower than 300mV and lasts more than 20ms, the inverter is latched shutdown. Toggling ENA restarts the operation.

Dimming Control

Three commonly used dimming functions, analog mode dimming, internal burst mode dimming and external LPWM burst dimming functions are available in OB3316 without any extra components. Different dimming modes are selected by BF/DMOD pin. The lamp brightness is determined by the control signal at DIM pin.

Supply a 5V (>3.5V) voltage to BF/DMOD pin to select analog mode dimming. A DC voltage ranging from 0V to 3V at DIM pin corresponds to a lamp brightness of approximately 40% to 100%.

External LPWM burst dimming mode is selected by shorting BF/DMOD pin to ground. OB3316 accepts an external LPWM signal to DIM pin with a swing voltage of 0V to >1.5V. 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, built-in 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. Duty cycle so as to lamp brightness is controlled by the analog signal at DIM pin. The burst mode dimming frequency F_{burst} is set by the following equation:

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

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

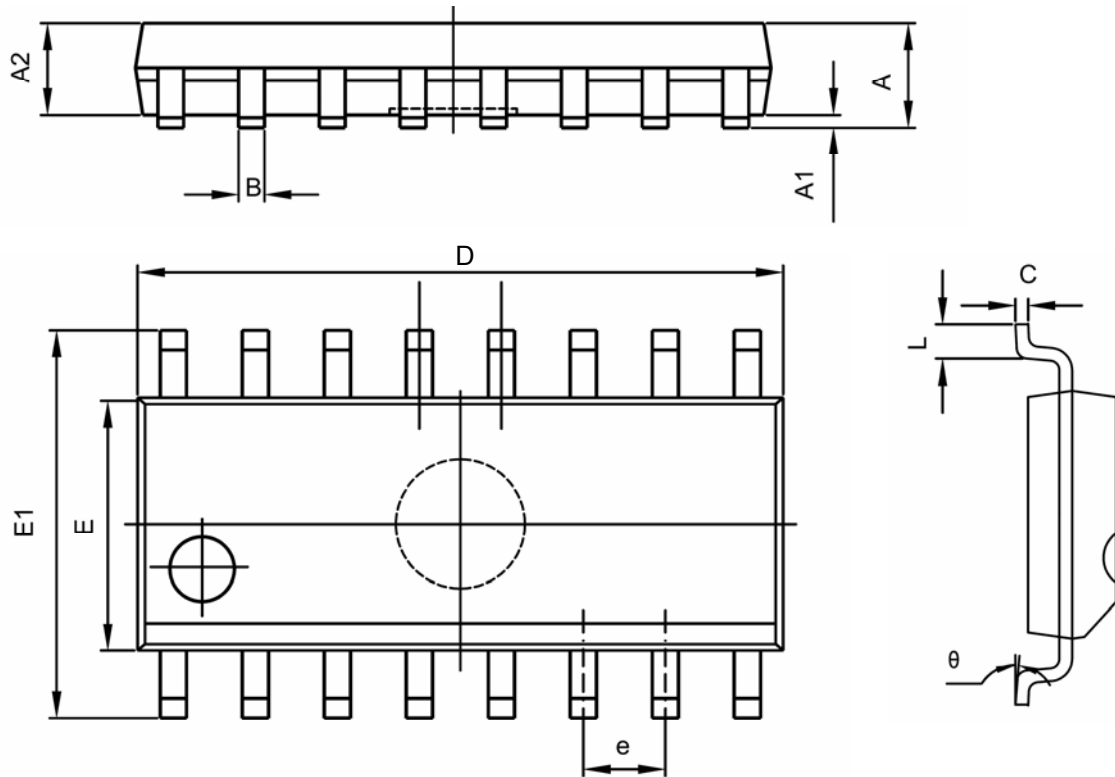| MODE	Analog	Internal Burst	External LPWM
BF/DMOD	>3.5V	Capacitor	<0.5V
DIM	0-3V	0-3V	External LPWM

# Reference Application Circuit for Single Lamp
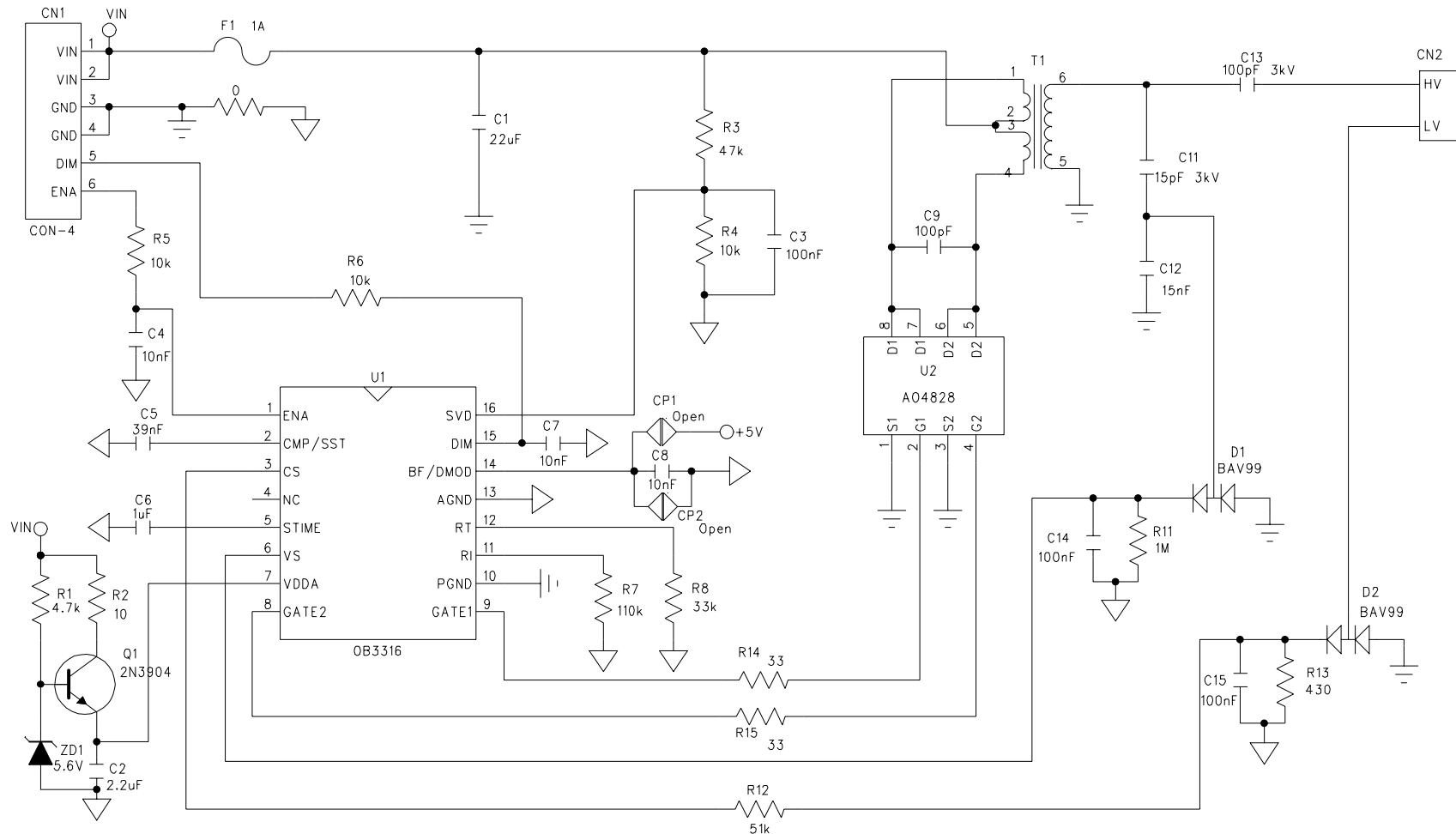
VIN: 8V Typical
DIM: 3V, Max. Brightness; 0V, Min. Brightness
ENA: Disable, 0-0.8V; Enable, 2-5V
LOAD: 100Kohm Dummy Load

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	0.170	0.250	0.007	0.010
D	9.800	10.200	0.386	0.402
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°

Package Mechanical Data: DIP16
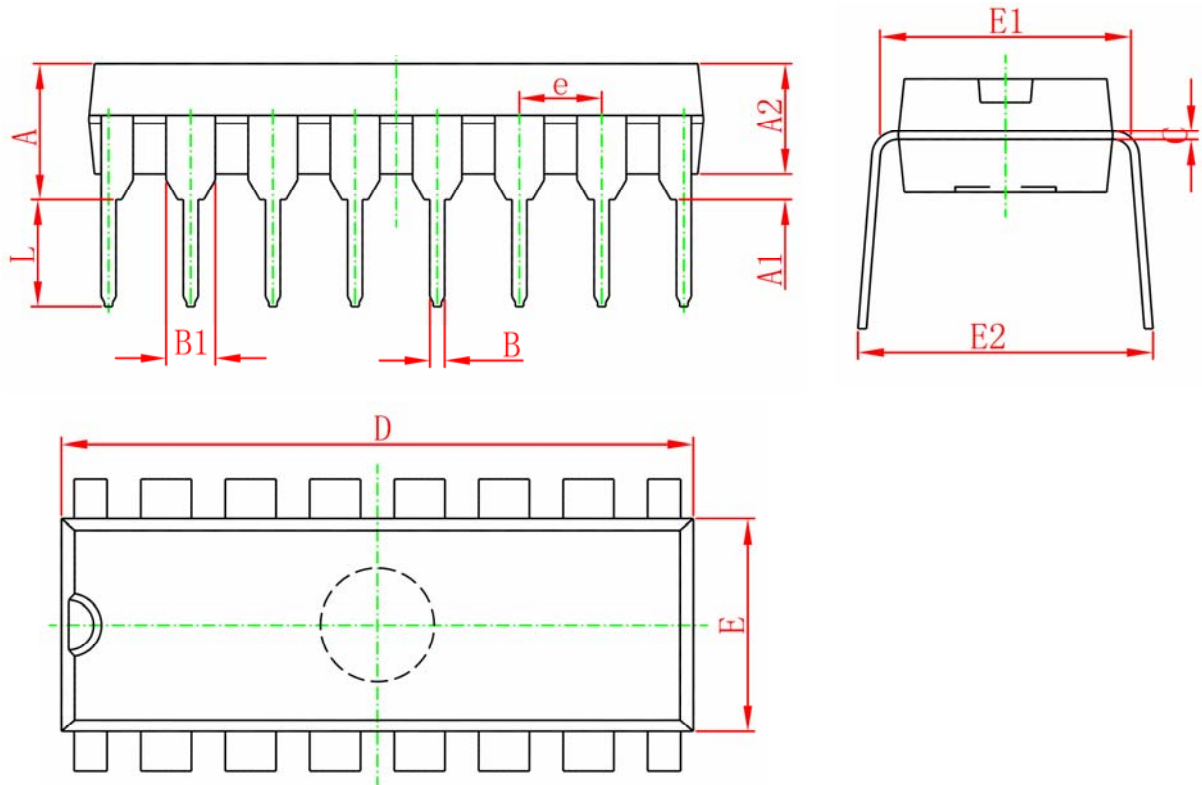
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.380	0.570	0.015	0.022
B1	1.524 (BSC)		0.060 (BSC)	
C	0.204	0.360	0.008	0.014
D	18.800	19.200	0.740	0.756
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
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

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