GENERAL DESCRIPTION

OB3600 is a dimmable, highly integrated buck regulator with advanced features to provide high efficiency control and high precision constant current output for LED lighting applications.
Proprietary Constant Voltage (CV) and Constant Current (CC) control is integrated as shown in the figure below.
The LED current (CC control) can be adjusted externally by the resistor Rs at CS pin.
OB3600 offers a dimmable function, the LED current can be controlled by setting the duty cycle of PWM waveform into the DC pin.
OB3600 offers comprehensive protection coverage with auto-recovery features including Cycle-by-Cycle current limiting, VDD OVP and UVLO. Excellent EMI performance is achieved with On-Bright proprietary frequency shuffling technique.
OB3600 is offered in SOP8 package.

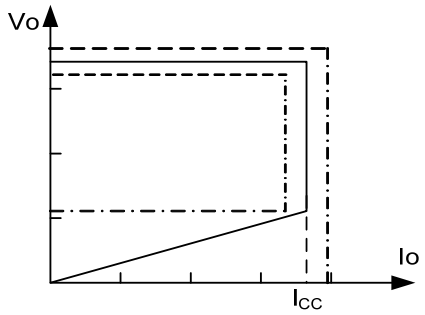


Fig.1. Typical CC/CV Curve

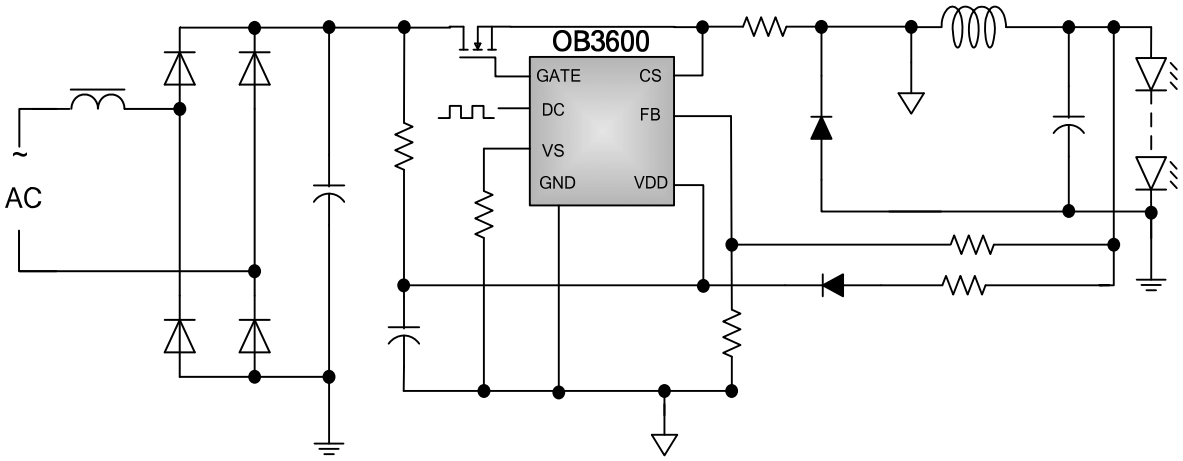
FEATURES

- High Precise Constant Current Regulation at Universal AC input
- Dimmable LED Current Control
- Quasi-Resonant operation
- Adjustable Constant Current, Constant Voltage
- Built-in Primary winding inductance compensation
- LED short circuit protection
- Built-in Leading Edge Blanking (LEB)
- Cycle-by-Cycle Current Limiting
- VDD Under Voltage Lockout with Hysteresis (UVLO)
- Latched over temperature protection (OTP)
- VDD OVP

APPLICATIONS

- Dimmable LED lighting

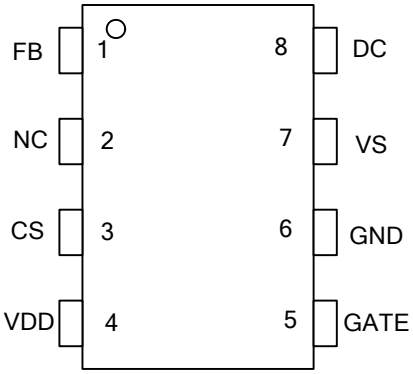
TYPICAL APPLICATION



GENERAL INFORMATION

Pin Configuration

SOP8.



Ordering Information

Part Number	Description
OB3600CP	SOP8, Pb-free in Tube
OB3600CPA	SOP8, Pb-free in T&R

Package Dissipation Rating

Package	RθJA (℃/W)
SOP8	150

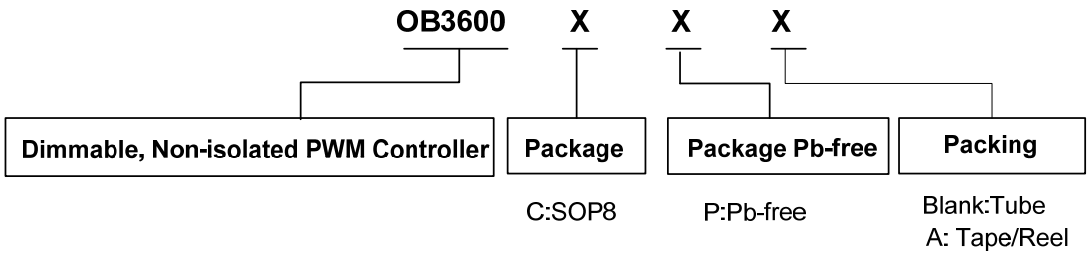
Absolute Maximum Ratings

Parameter	Value
Gate Voltage	-0.3 to 25V
VDD Voltage	-0.3 to V_{DD}_OVP
CS, FB, VS and DC Input Voltage	-0.3 to 7V
Min/Max Operating Junction Temperature T_J	-40 to 155 ℃
Operating Ambient Temperature T_A	-40 to 85 ℃
Min/Max Storage Temperature T_{stg}	-55 to 155 ℃
Lead Temperature (Soldering, 10secs)	260 ℃

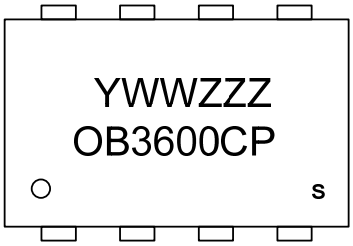
Note: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.

Recommended Operating Condition

Symbol	Parameter	Range
VDD	VDD Supply Voltage	12 to 25 V



Marking Information

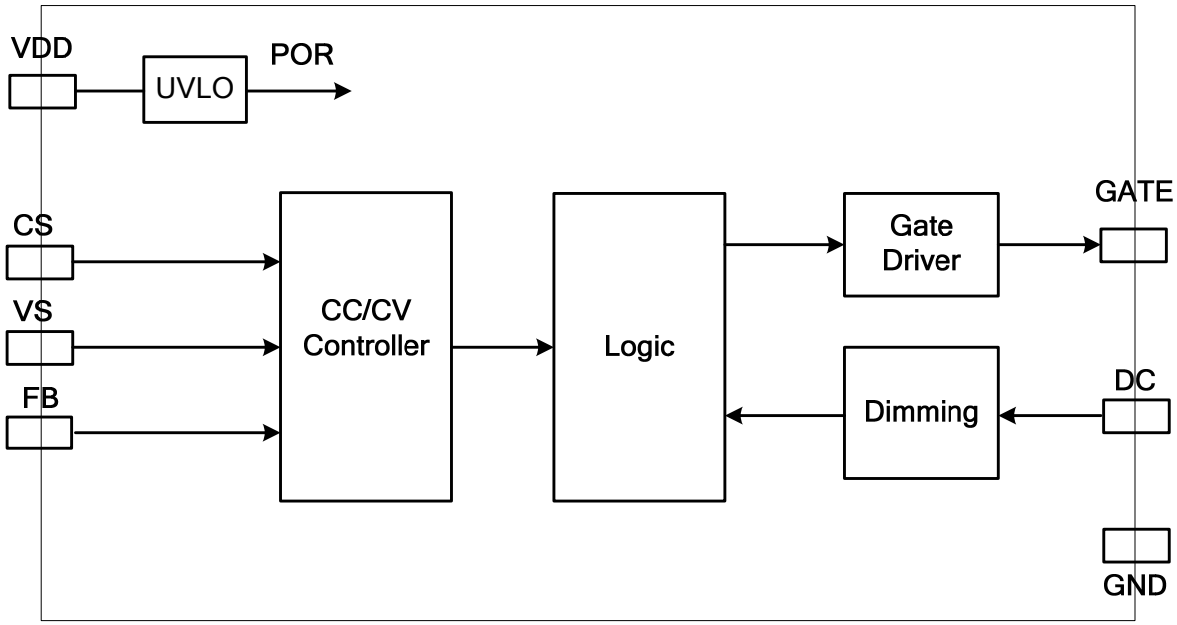


Y:Year Code
WW:Week Code(01-52)
ZZZ:Lot Code
C:SOP8 Package
P:Pb-free Package
S:Internal Code(Optional)

TERMINAL ASSIGNMENTS

Pin Num	Pin Name	I/O	Description
1	FB	I/O	Connected to resistor divider from primary winding or auxiliary winding to reflect output voltage
2	NC		No Connection
3	CS	I/O	Current Sense Input
4	VDD	P	Power Supply
5	GATE	O	Gate Driver Output
6	GND	P	Ground
7	VS	I/O	Dimming ON voltage reference select
8	DC	I/O	Dimming Control Input

BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

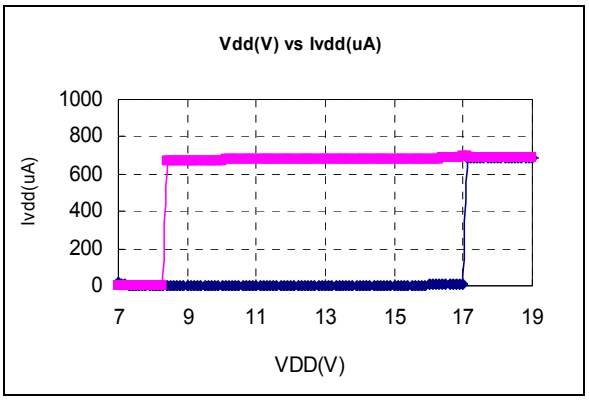
(TA = 25℃, VDD=16V, if not otherwise noted)

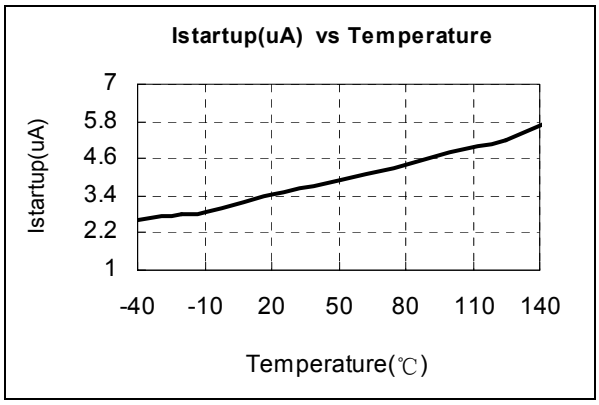
Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
Supply Voltage (VDD) section						
$I_{startup}$	Startup Current	VDD=UVLO_OFF-1V		4	20	uA
$I_{DD\ op}$	Operation Current	Operation supply current FB=1V, CS=0V, VDD= 20V	-	0.45	1	mA
UVLO(ON)	VDD Under Voltage Lockout Enter	VDD falling	7.3	8.3	9.3	V
UVLO(OFF)	VDD Under Voltage Lockout Exit	VDD rising	15.5	16.5	17.5	V
VDD_OVP	VDD over voltage protection		26	27	28.5	V
Current Sense Input section						
TLEB	LEB time			500		ns
Vth_oc	Over current threshold		492	500	508	mV
Td_oc	OCP Propagation delay			100		ns
Frequency section						
Freq_Max[Note]	IC Maximum frequency		144			KHz
Toff_min	Minimum Toff			2.0		us
F_min	Minimum frequency			114		Hz
△f/Freq	Frequency shuffling range			±3.5		%
Error Amplifier section						
Vref1_EA	Reference voltage 1 for EA		0.85	0.9	0.95	V
Vref2_EA	Reference voltage 2 for EA	Vs should be connected to GND	1.62	1.7	1.78	V
		Vs should be floated	2.28	2.4	2.52	V
		Vs should connect a resistor to GND	2.85	3	3.15	V
Gain	DC gain of EA			40		
Vth_OVP	Load OVP threshold voltage	Vs should be connected to GND		1.9		V
		Vs should be floated		2.7		V
		Vs should connect a resistor to GND		3.3		V
R_VS	Voltage reference select resistor @ Vref2=3V			270		KΩ
Gate Driver section						
VOL	Output low level @ VDD=14V, Io=5mA				1	V
VOH	Output high level @ VDD=14V, Io=20mA		6			V
V_clamping	Output clamp voltage			10		V
T_r	Output rising time 1V~ 9V@ CL=500pF			95		ns
T_f	Output falling time 9V~1V@ CL=500pF			50		ns
On chip over temperature section						
T_otp	Over temperature protection trigger point			155		℃
Dimming control section						
VH_DC	Threshold voltage for rising edge detection for DC pin		0.85	1	1.15	V
VL_DC	Threshold voltage for falling edge detection for DC pin		2.55	3	3.45	V

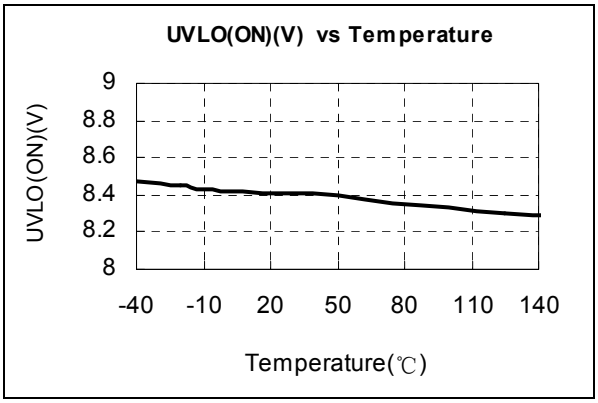
Note:

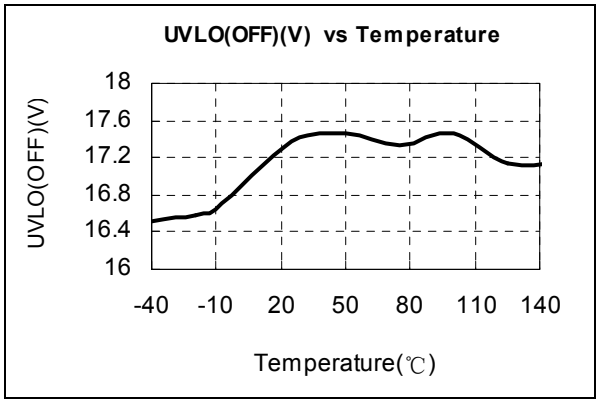
1. Freq_Max indicates IC internal maximum clock frequency. In system application, the maximum operation frequency of 144 KHz nominal occurs at maximum output power or the transition point from CV to CC.

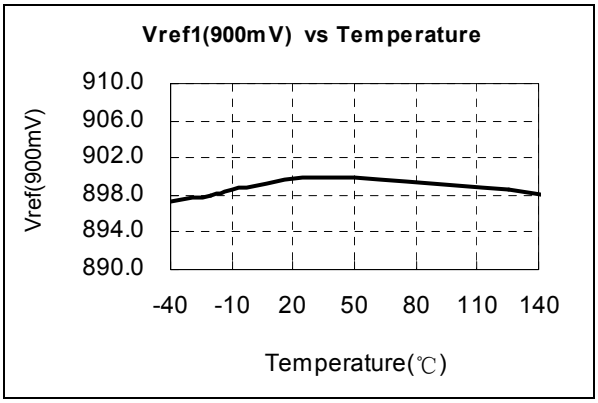
CHARACTERIZATION PLOTS

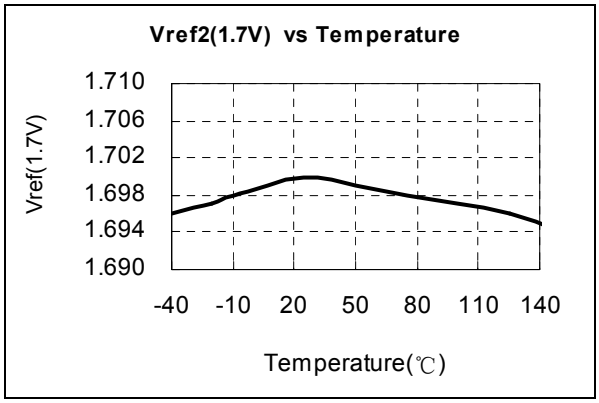


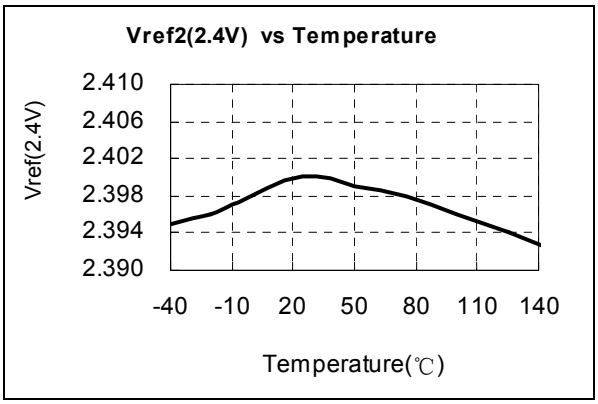


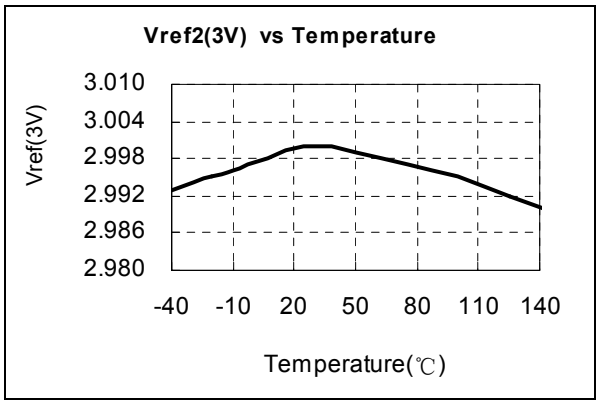


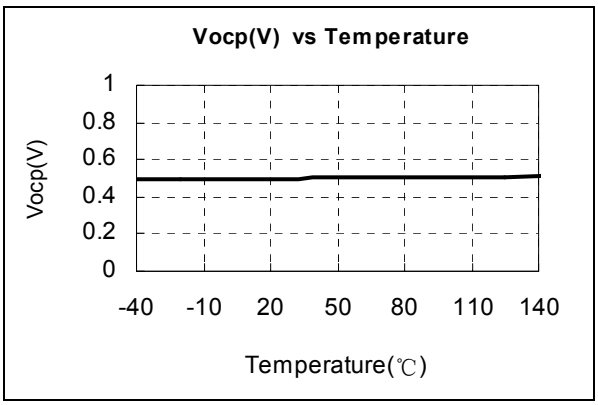











Vocp(V) vs Temperature
Vocp(V)
1
0.8
0.6
0.4
0.2
0
-40
-10
20
50
80
110
140
Temperature(℃)

OPERATION DESCRIPTION

OB3600 is a dimmable, non-isolated LED lighting controller which can achieve accurate current for LED lighting applications. Proprietary Constant Voltage (CV) and Constant Current (CC) control is integrated.

Startup Current and Start up Control

Startup current of OB3600 is designed to be very low so that VDD could be charged up above UVLO threshold and starts up quickly. A large value startup resistor can therefore be used to minimize the power loss in application.

Operating Current

The Operating current of OB3600 is as low as 0.45mA (Typ.). Typical good efficiency is achieved with the low operating current.

Principle of CC Operation

For buck type operating in transition mode, the peak voltage of CS is detected cycle-by-cycle, and compared with internal reference voltage, Vth_ocp (typical value 500mV).When the voltage at CS pin is up to the threshold voltage, the power switch will be turned off.

$$I_{pk} = \frac{V_{th\_ocp}}{R_{CS}} \quad (1)$$

Where, Rcs indicates the resistor at CS pin for primary side current sensing.

Refer to the equation 1, LED output current is

$$I_{LED} = \frac{I_{pk}}{2} = \frac{V_{th\_ocp}}{2 \times R_{CS}} \quad (2)$$

OB3600 works under transition mode and the on-time for power switch is

$$t_{on} = \frac{L \times I_{pk}}{V_{in} - V_{LED}} \quad (3)$$

Where L is the inductor of transformer at primary-side winding, Vin is line voltage after rectifying and V_{LED} is the voltage at LED.

When power switch turns off, the current flowing in the inductor will reduce to zero and the power switch will turn on after then. The off-time for power switch is

$$t_{off} = \frac{L \times I_{pk}}{V_{LED}} \quad (4)$$

The inductor could also be calculated by

$$L = \frac{V_{LED} \times (V_{in} - V_{LED})}{f \times I_{pk} \times V_{in}} \quad (5)$$

Where, f is the working frequency. The working frequency changes with input voltage. The lowest input voltage determines the lowest working frequency and the highest input voltage determines the highest working frequency.

The minimum and maximum off-time are set in OB3600. Therefore, the value of inductor should be carefully designed to achieve good LED output current, according to equation 4.

Adjustable CC point and Output Power

In OB3600, the CC point and maximum output power can be externally adjusted by external current sense resistor Rs at CS pin as illustrated in Typical Application Diagram. The output power is adjusted through CC point change. The larger Rs, the smaller CC point is, and the smaller output power becomes, and vice versa as shown in Fig.1.

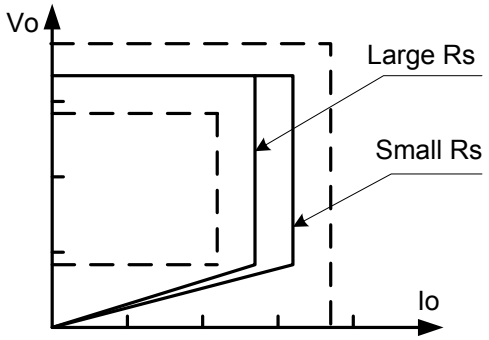


Figure.1 Adjustable output power by changing Rs

Operation switching frequency

The switching frequency of OB3600 is adaptively controlled according to the load conditions and the operation modes. No external frequency setting components are required. The operation switching frequency at maximum output power is set to 144KHz internally.

For buck operating in QR, The maximum output power is given by

$$P_{O\max} = \frac{1}{2}\eta L_P F_{SW} I_{pk}^2 \quad (4)$$

Where Lp indicate the inductance of winding and Ipk is the peak current of winding.

The principle of CC operation sets the product *Lp* and *fsw* to be a constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes. Up to +/-7% variation of the primary winding inductance can be compensated.

CV / OVP Mode

When LED string is open, an output voltage condition is monitored independently by the voltage at FB pin. During normal operation, the voltage at FB pin is regulated at 0.9 or 2.4V (VS pin floating), with dummy load over Pmin.

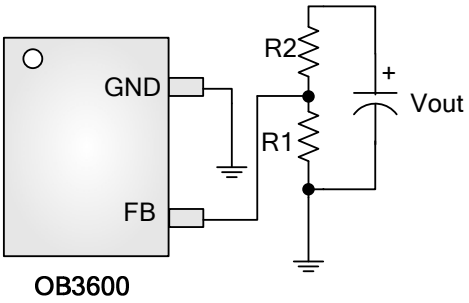


Figure.2 FB Section Circuit

$$V_{OUT} = \frac{R1+R2}{R1} \times V_{ref\_CV}$$

$$P_{\min} = \frac{1}{2} \times \left(\frac{Vth\_oc}{R_{CS}} \right)^2 F_{\min} L_{priamry}$$

V_{th_oc} — Over current protection threshold voltage

F_{min} — Minimum switching frequency, which is 103Hz (typ.)

If the dummy load is less than P_{min}, the output voltage rises up. If the voltage at FB pin exceeds a threshold of approximately 2.7V (VS pin floating), the over-voltage protection function is activated and the switching is turned off immediately.

$$V_{OVP} = \frac{R1+R2}{R1} \times V_{vth\_OVP}$$

CC Line Regulation

Adjust the R2 for better CC line regulation, while driving different type MOSFET. The larger MOSFET, the smaller R2 needed. If the resistance is too large, it causes the interference, too small resistance results the efficiency decreased at HV AC line.

Frequency shuffling for EMI improvement

The frequency shuffling (switching frequency modulation) is implemented in OB3600. The oscillation frequency is modulated so that the tone energy is spread out. The spread spectrum minimizes the conduction band EMI and therefore eases the system design.

Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in OB3600. The switch current is detected by a sense resistor into the CS pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial power MOSFET on state so that the external RC filtering on sense input is no longer needed.

Protection Control

Good power supply system reliability is achieved with its rich protection features including Cycle-by-Cycle current limiting (OCP), VDD OVP, on-chip OTP, and Under Voltage Lockout on VDD (UVLO).

Latched Over Temperature Protection

Over temperature protection is offered in OB3600. When temperature of the device rises over 155℃ (typical), the switching frequency will decrease to half. And the state will be kept until the device restarts.

UVLO

VDD is supplied by transformer winding output. The output of OB3600 is shut down when VDD drops below UVLO (ON) limit and the power converter enters power on start-up sequence thereafter.

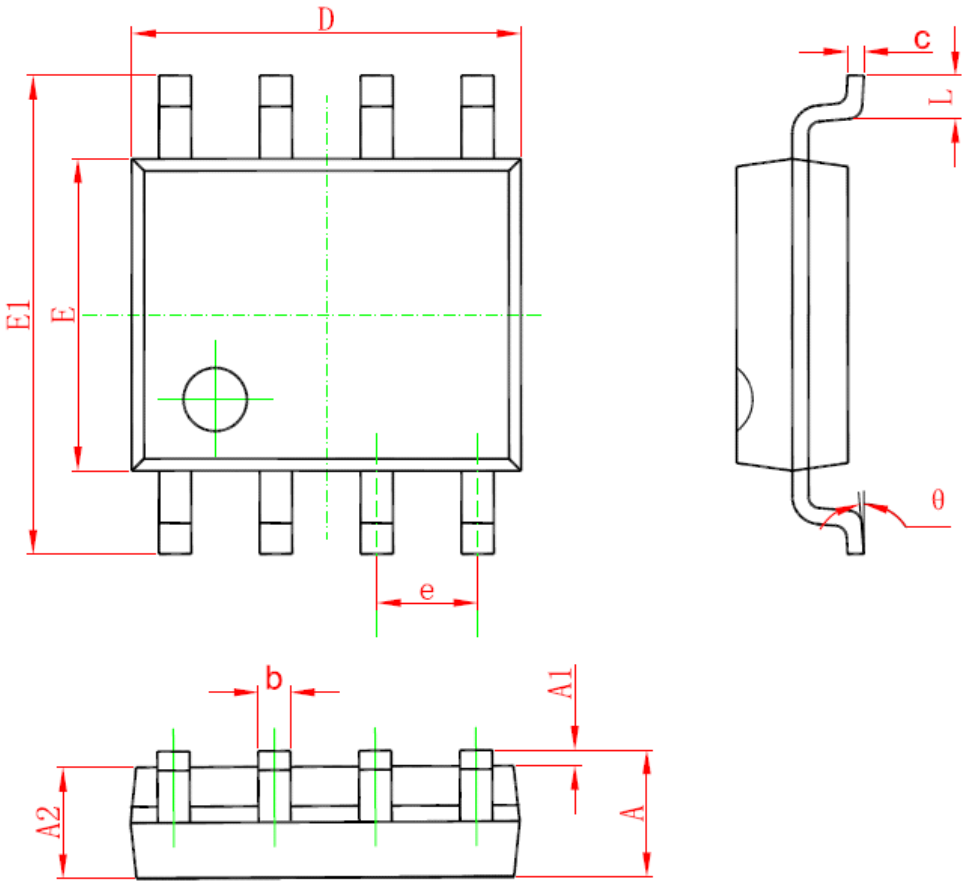
Dimming (Error Amplifier Reference Voltage Switch) Control

Dimming (Error Amplifier Reference Voltage switch) control is offered in OB3600. Default the DC pin is pulled up with 1mA current source. The error amplifier reference voltage is 0.9V. If the DC pin is pulled down, the error amplifier reference voltage is switched to 2.4V (VS pin floating). Dimming ON voltage reference offering pin programmable selection of three popular voltage 1.7V, 2.4V, 3V. The connecting of the programming pin as shown in table:

VS pin connecting	Vref2	Vth_OVP
Connecting to GND	1.7V	1.9V
Floating	2.4V	2.7V
Connecting to GND with 270K resistor	3V	3.3V

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	0.170	0.250	0.006	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)		0.05 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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 application 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.