

## Constant Current Controller For Non-isolated Buck LED Driver

### Features

- Inductor Current Critical Mode, No Need to Compensate the Inductance Variation
- Source Driver Structure, Not Need the Auxiliary Winding for VCC
- $\pm 3\%$  LED Current Accuracy
- Up to 93% System Efficiency
- LED Short Circuit Protection
- Current Sense Resistor Short Circuit Protection
- Over Temperature Protection
- Programmable LED open protection

### Applications

- LED Bulb
- LED Candle light
- LED Spot light
- Decorative LED lighting

### General Description

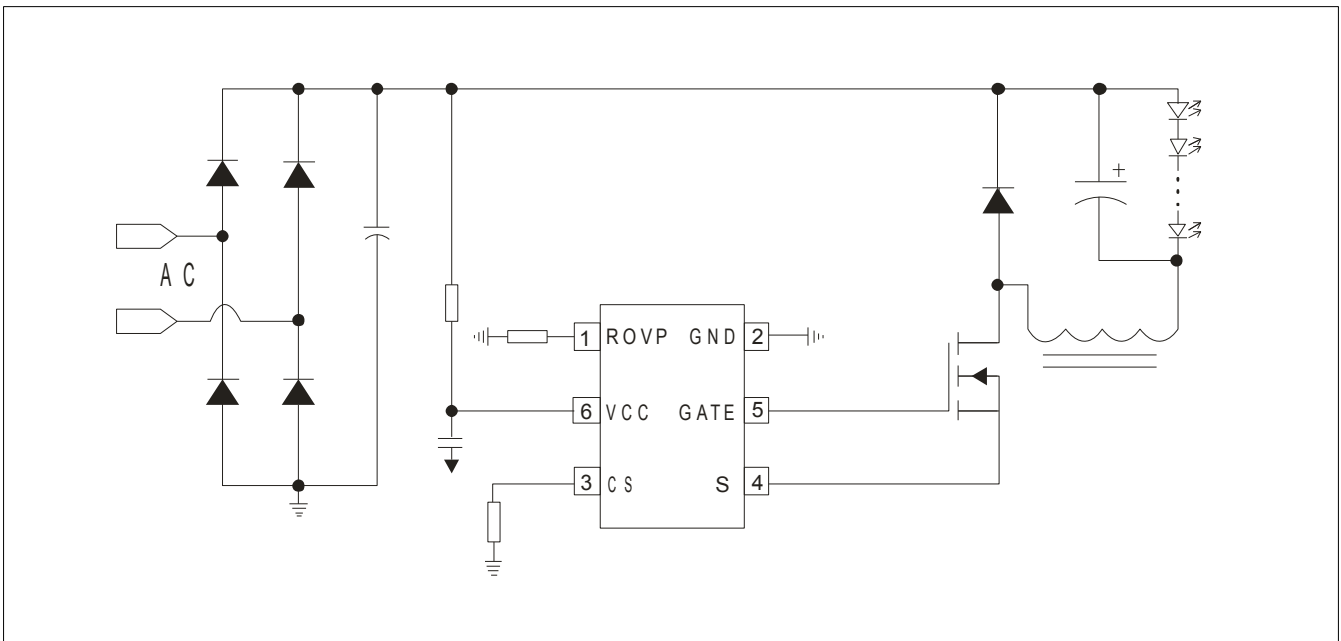
The WS3440 is a high precision constant current controller, designed for non-isolated buck LED driver. suitable for AC input voltage range (84V-264V)

The WS3440 uses high precision current sense circuit and patent method for constant current control, to achieve high precision output current and excellent line regulation. The WS3440 operates in inductor current critical mode. The LED current is constant over wide range of inductance variation and the LED output voltage, so the load regulation is excellent.

The WS3440 uses patent source driver architecture. The operation current is 200uA only, so the auxiliary winding is not needed. It can simplify the system design and reduce the system cost.

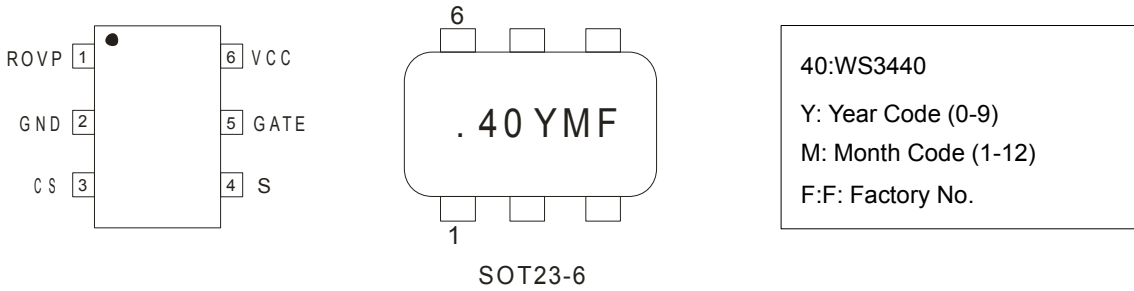
The WS3440 offers rich protection functions, including LED open/short circuit protection, current sense resistor short circuit protection and over temperature protection.

### Typical Application Circuit



**Pin Definition and Device Marking**

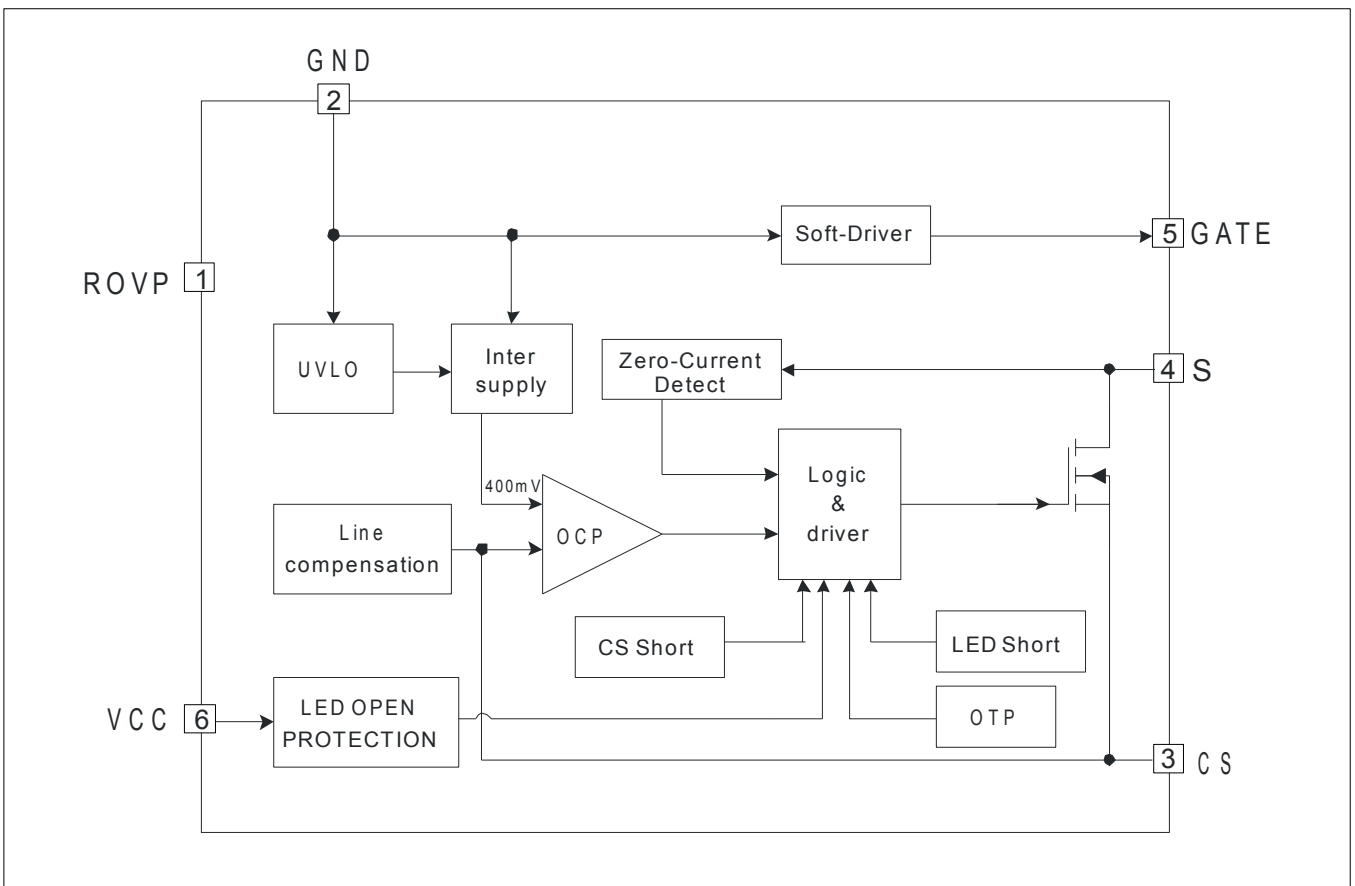
WS3440 is available in SOT23-6 package:



**Pin Function Description**

Pin Name	Pin NO.	Description
ROVP	1	Programmable LED open protection pin, connect a resistor to GND
GND	2	Ground
CS	3	Current sense input, the sense resistor is connected from CS to ground
S	4	HV power MOSFET source
GATE	5	HV power MOSFET gate
VCC	6	Power supply

**Block Diagram**



### Ordering Information

Package	Part Number	Marking
6-Pin SOT23-6, Pb-free	40 YMF	WS3440YP

### Recommended Operating Condition

symbol	parameter	value	units
$I_{LED}$	Output LED Current	< 300	mA

### Absolute Maximum Ratings

symbol	parameter	Range	Units
$I_{CC\_MAX}$	VCC pin maximum sink current	2.5	mA
$V_{ROVP}$	ROVP input voltage	-0.3~7	V
$V_S$	HV MOSFET source voltage	-0.3~8	V
$V_{CS}$	Current sense pin input voltage	-0.3~7	V
$P_{DMAX}$	Power dissipation	0.9	W
$T_J$	Operating junction temperature	150	°C
$T_{STG}$	Storage temperature range	-55~150	°C

Note: Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. Under “recommended operating conditions” the device operation is assured, but some particular parameter may not be achieved.

**Electrical Characteristics** (Unless otherwise specified,  $T_A=25^{\circ}\text{C}$ ,  $V_{CC}=7\text{V}$ )

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage Section						
Vcc_clamp	VCC Clamping Voltage		7.0	7.3	7.6	V
Icc_clamp	VCC Clamping Current				2.5	mA
VCC_ST	VCC Start Up Voltage	VCC Rise	6.6	6.9	7.2	V
Vuvlo_HYS	VCC Under Voltage Latch Out Hysteresis	VCC Falling		1.5		V
Ist	Start Up Current	$V_{CC} < V_{CC\_ST} - 0.5\text{V}$		45	60	uA
Iop	Operation Current			200		uA
Current Sensor Section						
Vcs_th	Current Sensor Voltage Threshold		390	400	410	mV
TLEB	Leading Edge Blanking			350		ns
TDELAY	Turn Off Delay Time			300		ns
Internal Driver Section						
TOFF_MIN	Minimum Demagnetization Time			4		us
TOFF_MAX	Maximum Demagnetization Time			240		us
TON_MAX	Maximum Turn On Time			40		us
ROVP Section						
VROVP	Internal reference voltage			0.5		V
Over Temperature Section						
TSD	Thermal Shut Down Temperature			160		$^{\circ}\text{C}$
TSD_HYS	Thermal Shut Down Hysteresis			20		$^{\circ}\text{C}$
T_comp	Intelligent temperature compensation function			140		$^{\circ}\text{C}$
Drive ability Section						
I <sub>max</sub>	Built-in power tube maximum peak current				1.3	A

Note: I<sub>max</sub> depends on the ambient temperature and cooling conditions chips work at high temperatures I<sub>max</sub> will be reduced.

**Function Description**

WS3440 is a constant current controller, designed for driving non-isolated buck LED power supply. WS3440 uses patent constant current control method and source driver structure, excellent constant current characteristic is achieved with low counts components. Low cost and high efficiency of system is realized.

**Start up**

The Vcc will be charged through the startup resistor when the system is powered on. When the voltage on Vcc reaches the startup voltage threshold, the controller starts to switching. The Vcc voltage of WS3440 is clamped to 7.3V by internal Zener diode.

**Constant Current Control and Output Current Setting**

The WS3440 uses patent constant current control method, excellent constant current is achieved with low counts components. The WS3440 senses the peak current in inductor cycle by cycle. The CS Pin is connected to the input of internal current comparator, and compared with the internal 400mV reference voltage. The external power MOSFET will be turned off when the CS pin voltage reaches the voltage threshold. The comparator has a 350ns LEB timer to avoid mis-trigger.

The peak current in the inductor is given by:

$$I_{PK} = \frac{400}{R_{CS}} (mA)$$

The Rcs is the resistance of current sense resistor The current in LED can be calculated by the following equation:

$$I_{LED} = \frac{I_{PK}}{2}$$

The IPK is the peak current in inductor

**Source Driver Structure**

The WS3440 uses the patent source driver structure. The typical operation current is as low as 200uA, the auxiliary winding is not need. So the system design is simple and the

cost is low.

**Inductance Calculation**

The WS3440 is designed to work in inductor current critical mode; the energy will be stored in the inductor when the MOSFET is turned on. The turn on time is given by:

$$t_{on} = \frac{L \times I_{PK}}{V_{IN} - V_{LED}}$$

The L is the inductance. The Ipk is the peak current in inductor. The VIN is the input rectified voltage. The VLED is the voltage on LED.

When the power MOSFET is turned off, the inductor current will decrease from the peak current to zero. The turn off time is given by:

$$t_{off} = \frac{L \times I_{PK}}{V_{LED}}$$

The MOSFET will be turned on again when it detects the inductor current goes to zero. The inductance can be calculated by the following equation:

$$L = \frac{V_{LED} \times (V_{IN} - V_{LED})}{f \times I_{PK} \times V_{IN}}$$

The f is the system switching frequency, which is proportional to the input voltage. So the minimum switching frequency is set at lowest input voltage, and maximum switching frequency is set at highest input voltage.

The WS3440 internally set the minimum off time to 4us and maximum off time to 240 us. When the inductance is very small, the toff may goes below the minimum off time and the inductor current becomes discontinuous. So the output LED current will be smaller than the setting value. If the inductance is too large, the toff may goes beyond the maximum off time and the inductor current becomes continuous. And the output LED current will be larger than the setting value. So it's very important to select a right inductance.

The WS3440 also internally set the maximum on time to 40us. When the input voltage is very low or LED output

voltage is very high, the ton may goes beyond the maximum on time. The power MOSFET will be turned off even the inductor current still below the setting value. So the output LED current will be smaller than the setting value.

### Set open protection

The LED open protection voltage can be set by adjusting the value of the resistor connecting from ROVP to GND.

In the LED open condition, the output voltage will raise graduate, and the demagnetize time will shorten as well, the demagnetize time  $T_{ovp}$  can be calculator as below:

$$T_{ovp} = \frac{L \times V_{CS}}{R_{CS} \times V_{OVP}}$$

In which the  $V_{CS}$  is the OCP threshold (0.4V), the  $V_{ovp}$  is the target output protection voltage. And the value of the resistor  $R_{ovp}$  is as below:

$$R_{ovp} = 15 * T_{ovp} * 10^6 \quad (\text{K}\Omega)$$

### Protection Functions

The WS3440 has many protection functions, including LED open/short circuit protection, current sense resistor short circuit protection and over temperature protection. All of the

protection functions are designed to auto-recover. The over temperature protection circuitry in the WS3440 monitors the die junction temperature after start up. When the temperature rises to 150°C, the power MOSFET will be shut down immediately and maintains at switch off condition until the temperature on die falls 30°C below the thermal protection trigger point.

### PCB Layout

The following guidelines should be followed in WS3440 PCB layout:

#### Bypass Capacitor

The bypass capacitor on VCC pin should be as close as possible to the VCC and GND pins.

#### Ground Path

The power ground path for current sense should be short, and the power ground path should be separated from small signal ground path before the negative node of the bus capacitor.

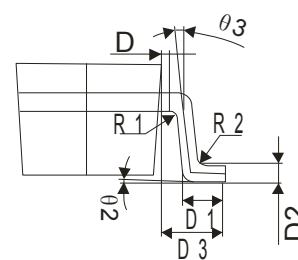
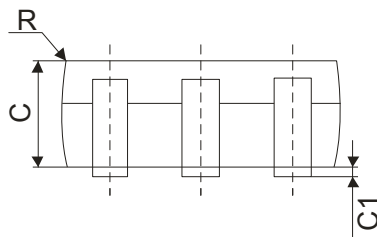
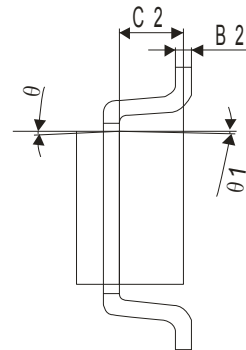
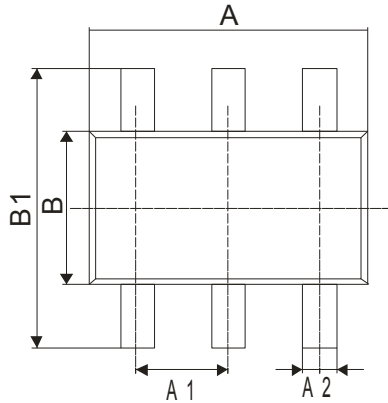
#### The Area of Power Loop

The area of main current loop should be as small as possible to reduce EMI radiation. And the controller should be placed away from the heat generator, such as the power diode.

**Package Information**

**SOT23-6 Package Outline Dimensions**

Unit:mm



Symbol	Winsemi			
	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	2.72	3.12	0.107	0.123
B	1.40	1.80	0.055	0.071
C	1.00	1.20	0.039	0.047
A1	0.90	1.00	0.035	0.039
A2	0.30	0.50	0.012	0.020
B1	2.60	3.00	0.102	0.118
B2	0.119	0.135	0.005	0.005
C1	0.03	0.15	0.001	0.006
C2	0.55	0.75	0.022	0.030
D	0.03	0.13	0.001	0.005
D1	0.30	0.60	0.012	0.024
D2	0.25TYP		0.01TYP	
D3	0.60	0.70	0.024	0.028

**NOTE:**

1. We strongly recommend customers check carefully on the trademark when buying our product, if there is any question, please don't be hesitate to contact us.
2. Please do not exceed the absolute maximum ratings of the device when circuit designing.
3. Winsemi Microelectronics Co., Ltd reserved the right to make changes in this specification sheet and is subject to change without prior notice.

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