

WS3230 High PF PSR Constant Current LED Driver

Features

- $\pm 5\%$ LED Current Accuracy
- Primary-side Sensing and Regulation Without TL431 and Opto-coupler
- No Auxiliary Winding For Sensing And Supplying
- High Power Factor Correction
- Ultra low operating current
- LED Open/Short Circuit Protection
- CS Resistor Short Circuit Protection
- VCC over voltage protection & under voltage lockout(UVLO)
- Over Temperature Protection

Applications

- GU10 LED driver
- LED spot light
- Other LED lighting

General Description

WS3230 is a high precision QR primary-side feedback and regulation controller for LED lighting, optimized for flyback converter with the output power less than 30W.

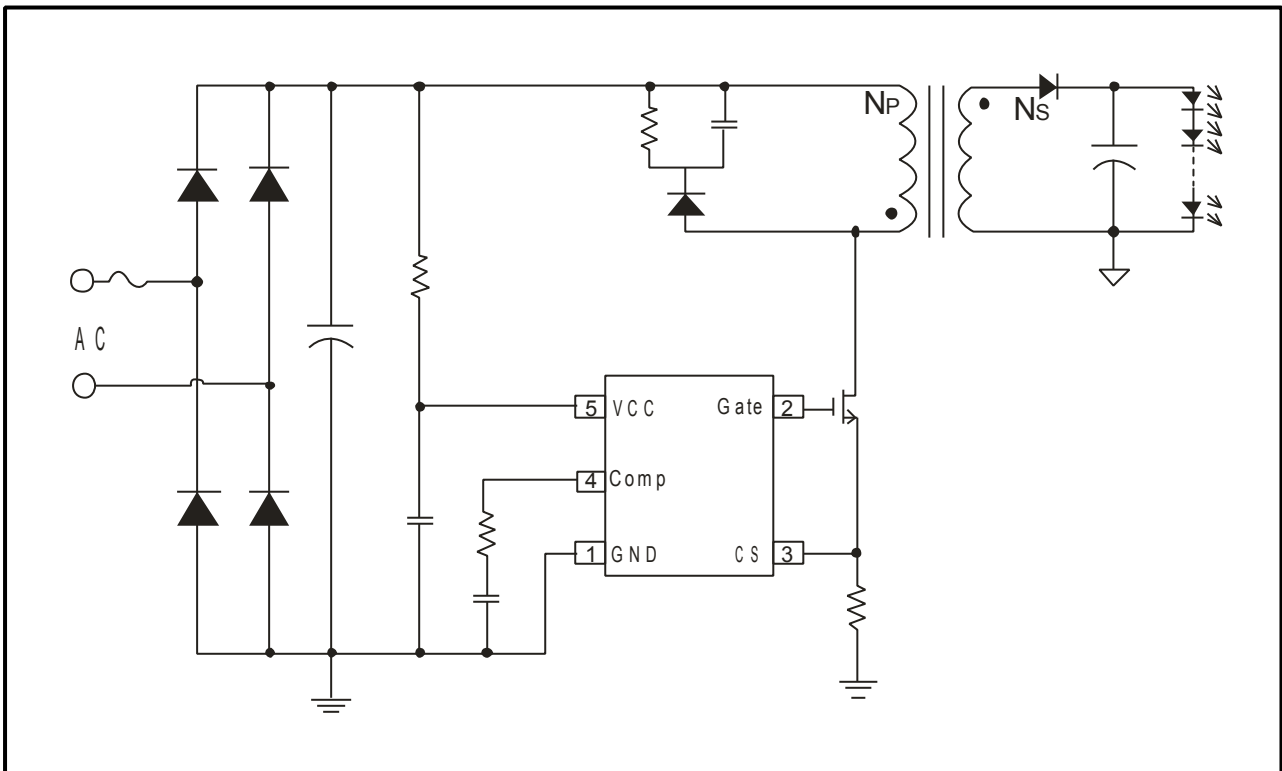
Since adopting primary sense and feedback control technology, the secondary sense and feedback circuit is eliminated. And WS3230 does not need the auxiliary winding for sensing the output current and supplying the chip. The low component counts and small system size are realized.

Since using the high accurate current sense method, WS3230 realizes $\pm 5\%$ accuracy of LED current along with excellent line and load regulation.

WS3230 offers comprehensive protection including Cycle-by-Cycle current limiting (OCP), LED open/short circuit protection, CS resistor short circuit protection, VCC UVLO,OVP and Clamp, and over temperature protection.

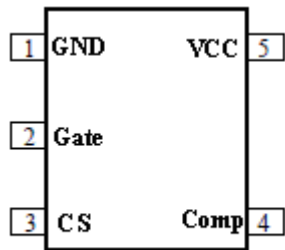
WS3230 is available in SOT23-5 package.

Typical Application Circuit

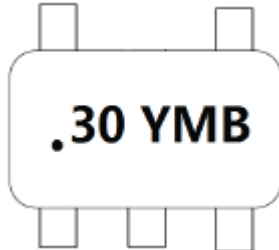


Pin Definition and Device Marking

WS3230 is available in SOT23-5 package:



SOT23-5

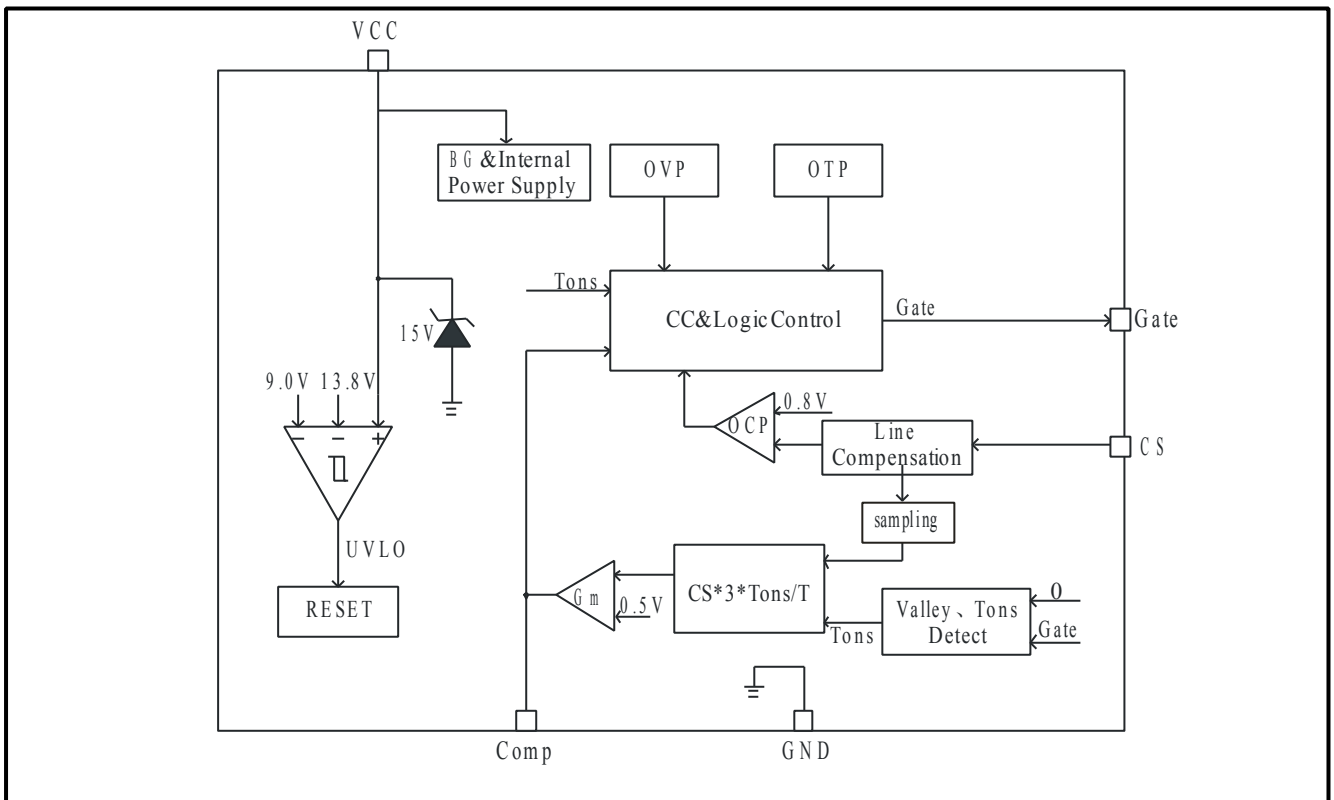


30: WS3230
Y: Year Code (1:2011; 2:2012.....)
M: Month Code (1-12)

Pin Function Description

Pin Name	Pin Number	Pin Type	Function Description
GND	1	Ground	Ground.
Gate	2	Output	Totem-pole gate drive output for the power MOSFET.
CS	3	Current Sense	Current sense. This pin connects a current sense resistor to GND to detect the primary current of transformer.
Comp	4	Loop Compensation	Loop compensation pin. Connect a RC network across this pin and ground to stabilize the control loop.
VCC	5	Power Supply	Power supply.

Block Diagram



Ordering Information

Package	IC Marking Information	Purchasing Device Name
SOT23-5, Pb-free	30 YMB	WS3230YP

Recommended Operating Condition

Symbol	Parameter	Value	Unit
VCC	VCC supply voltage	9~14	V
T _A	Operating temperature	-20~85	°C

Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
I _{CC_max}	VCC pin maximum sink current	5	mA
Gate	Driver output	-0.7~40	V
CS	CS pin input voltage	-0.3~7	V
Comp	Comp pin input voltage	-0.3~7	V
T _J	Operating junction temperature	-40~150	°C
T _{STG}	Min./Max. Storage temperature	-55~150	°C

Note: Stresses above 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 in the Recommended Operating Conditions section are not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.

Electrical Characteristics (T_A=25°C, VCC=14V, if not otherwise noted)

symbol	parameter	Test condition	Min	Typ	Max	Unit
Supply Voltage (VCC)						
I_VCC_ST	Start up current	VCC=UVLO_ON-1V		60	100	uA
I_OP	Operation Current	Fop=7Khz		170	300	uA
UVLO_ON	Turn on threshold Voltage	VCC rising		12.7		V
UVLO_OFF	Turn-off threshold Voltage	VCC falling		10		V
VCC_Clamp	VCC Clamp voltage	Icc=5mA		15		V
Current Sense Section						
TLEB	Leading edge Blanking Time			500		ns
V _{TH_OC}	OCP threshold		485	500	515	mV
Tdelay	Switch off delay time			200		ns
Frequency Section						
Ton_max	Max Primary On Time			24		us
Toff_max	Max Primary Off Time			224		us
Driver Section						
Isource	Gate sourcing current	VCC=14V, Gate=0V		284		mA
Isink	Gate sinking current	VCC=Gate=14V		202		mA
VOH	Output voltage high	VCC=14V, I _o =20mA	9.5			V
VOL	Output voltage low	VCC=14V, I _o =-20mA			0.45	V
Tr	Rising time	VCC=14V, C _{gate} =1nF		183		ns
Tf	Falling time	VCC=14V, C _{gate} =1nF		69.5		ns
Over Temperature Protection						
Tsd	Thermal shutdown threshold			150		°C
Tsd_hys	Thermal shutdown hysteresis			25		°C

Function Description

WS3230 is a high-integrated offline QR PSR controller, optimized for low power LED driver. WS3230 operates in primary-side sensing and regulation. Consequently, opto-coupler and TL431 could be eliminated, thus reduce the cost.

Startup Current

Startup current of WS3230 is designed to as low as 60uA. The VCC capacitor will be charged through the start-up resistor when the system is powered on. Once the VCC voltage reaches the start-up threshold, the WS3230 will start to switch. The WS3230 integrates a 15V zener for VCC clamping. Due to the ultra-low operating current, the auxiliary winding is not need to supply the IC.

Quasi-Resonant Operation

Quasi-Resonant switching mode is applied in WS3230. When the voltage across drain and source of the primary MOSFET is at voltage valley, the MOSFET would be turned on, reducing the switching losses and improving EMI performance.

CC Operation

WS3230 is designed to produce good CC control characteristic. In DCM mode, the output current I_o can be represented by,

$$I_o = 0.5 * I_{ps} * T_{ons} / T$$

Where I_{ps} is the peak current of the secondary side; T_{ons} is the turn on time of secondary side; T is the switching period.

$$I_{ps} = I_{pp} * N_{ps} = (V_{cs} / R_{cs}) * N_{ps}$$

Where I_{pp} is the primary peak current; V_{cs} is the voltage on CS resistor; R_{cs} is primary current detection resistor; N_{ps} is the turns ratio of primary to secondary of the flyback transformer. The relationship of V_{cs} , T_{ons} and T is controlled to be constant by internal circuit, $3 * V_{cs} * T_{ons} / T = 0.5V$. Thus, I_o can be represented by,

$$I_o = 0.5 * (V_{cs} / R_{cs}) * N_{ps} * T_{ons} / T$$

$$= (V_{cs} * T_{ons} / T) * 0.5 * (N_{ps} / R_{cs})$$

$$= 0.083 * (N_{ps} / R_{cs})$$

Once the parameters of the transformer and the current sense resistor R_{cs} is determined, so is the output current. And the output current can be set by adjusting the current sense resistor R_{cs} .

Internal pre-charge design for quick start up

After VCC exceeds UVLO_ON, V_{comp} is pre-charged by an internal current source. The PWM block will not start to output PWM signals until V_{comp} is over 0.45V. Such design is meant to reduce the start up time. The voltage pre-charged V_{comp} in start-up procedure can be programmed by,

$$V_{comp} = 0.4V - 300uA * R_{comp}$$

Where R_{comp} is the series resistor of Comp pin.

Operation switching frequency

The frequency of WS3230 is decided by load condition and QR mode. When the output power decreases, the switching frequency can become rather high. The maximum switching frequency in WS3230 is internally limited to 120Khz.

Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in WS3230. The switch current is detected by a sense resistor into the sense pin. An internal leading edge blanking circuit chops off the sense voltage spike at initial MOSFET on state due to snubber diode reverse recovery so that the external RC filtering on sense input is no longer required. The current limit comparator is disabled and thus cannot turn off the external MOSFET during the blanking period.

Protection Controls

Excellent system stability is achieved by the comprehensive protection of WS3230. Including

Cycle-by-Cycle current limiting (OCP), LED open/short circuit protection, CS resistor short circuit protection, VCC UVLO,OVP and Clamp, over temperature protection, and so on.

When the LED is open circuit, it will trigger over-voltage protection logic and latch, the system stops switching immediately; When the LED short circuit is detected, the system works at low frequency($F_{op}=5KHz$), so the power loss is low. At some catastrophic fault condition, such as shorted CS resistor or flyback transformer saturation, the internal fast fault detection circuit will trigger and latch, the system stops switching immediately.

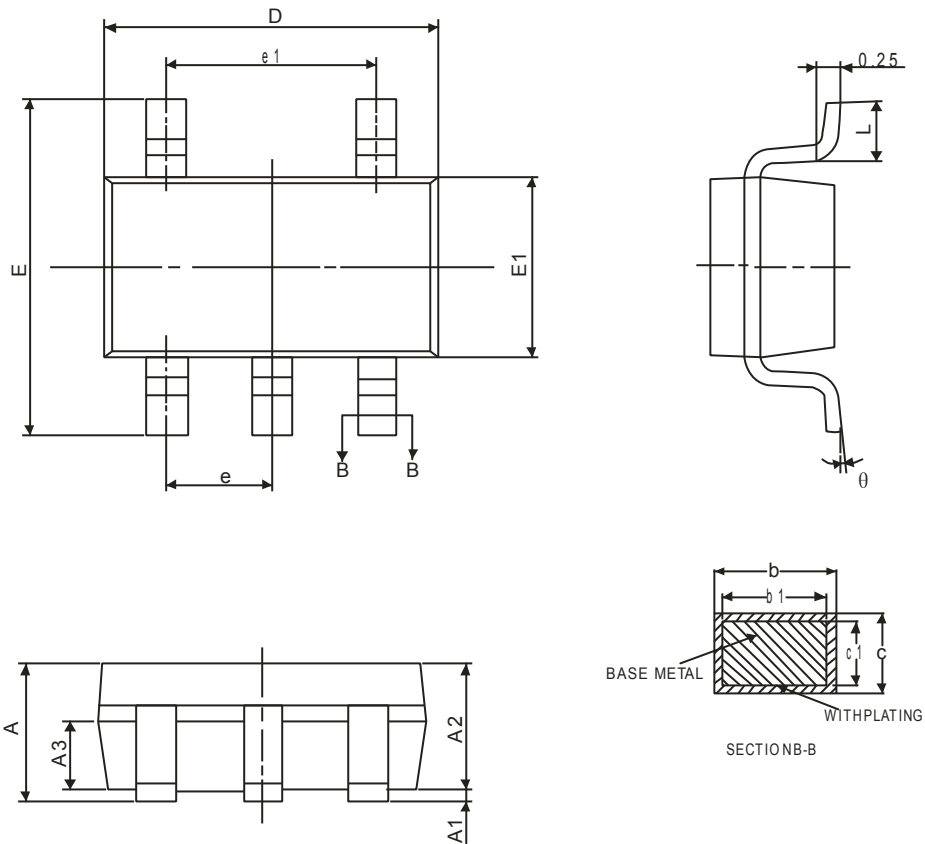
After the system enters into fault latch condition, the VCC voltage will fall until it reaches UVLO threshold. Then the system will re-start again. If the fault condition is removed,

the system will recover to normal operation.

The thermal shutdown circuitry in the WS3230 senses the die temperature after start up, and the thermal protection threshold is set to $150^{\circ}C$ with a $25^{\circ}C$ hysteresis. When the temperature on die of WS3230 rises and reaches the threshold, the power MOSFET will be shut down immediately and maintained switch off until the temperature on die falls $25^{\circ}C$ from thermal protection trigger point

Package Information

SOT23-5 Package Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	-	1.35	-	0.0531
A1	0.04	0.15	0.0016	0.0059
A2	1.00	1.20	0.0394	0.0472
A3	0.55	0.75	0.0217	0.0295
b	0.38	0.43	0.0150	0.0169
b1	0.37	0.43	0.0146	0.0169
c	0.11	0.21	0.0043	0.0083
c1	0.10	0.16	0.0039	0.0063
D	2.72	3.12	0.1071	0.1228
E	2.60	3.00	0.1024	0.1181
E1	1.40	1.80	0.0551	0.0709
e	0.95 BSC		0.0374BSC	
e1	1.90 BSC		0.075BSC	
L	0.30	0.60	0.0118	0.0236
θ	0°	8°	0°	8°