Non-isolated Buck APFC Offline LED Driver

Features

- **Specially Optimized for the EMI**
- Internal 600V Power MOSFET
- Active PFC for High Power Factor and Low THD
- Critical Conduction Mode Operation
- System Efficiency up to 95%
- Without auxiliary winding
- Excellent Line and Load Regulation
- ±3% LED Output Current Accuracy
- Thermal Regulation Function
- LED Short/Open Protection
- Current Sensing Resistor Open Protection
- Auto Fault Recovery
- Available in SOP7 Package

Applications

- E27 LED Bulb, Spot Light
- PAR30, PAR38 Lamp
- T8/T10 LED String
- Other LED Lighting

Description

The WS3412AH is a high precision non-isolated buck driver with active PFC, specially designed for universal input offline constant current LED lighting. The driver with on-chip PFC circuit achieves high power factor and low THD. Operating in critical conduction mode, the power MOSFET switching loss is reduced and the inductor is fully utilized.

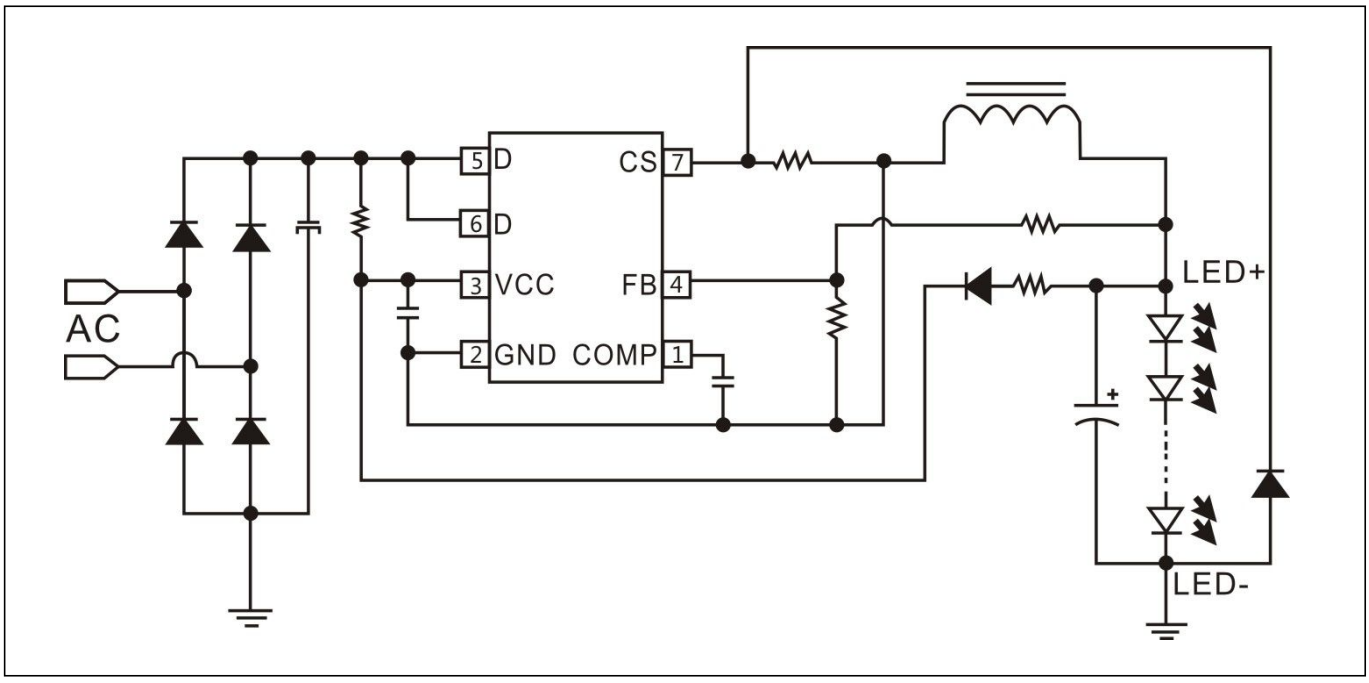
The WS3412AH integrates a 600V power MOSFET. With few external components, the LED output current can be precisely controlled.

The WS3412AH offers rich protection functions to improve the system reliability, including LED open circuit protection, LED short circuit protection, CS resistor open circuit protection and cycle by cycle current limit. All the protection functions are auto-recovery. The system reliability is further improved by the thermal regulation function. The output current is reduced when the driver is over temperature.

The WS3412AH has ultra low start up current and ultra low operating current.

The WS3412AH is available in SOP7 Package.

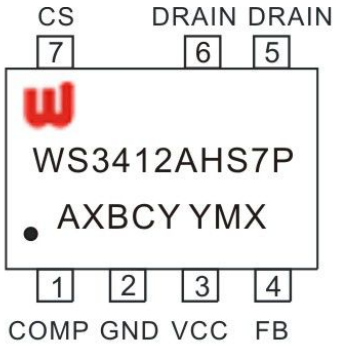
Typical Application



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Pin Configuration and Marking Information

The WS3412AH is available in SOP7 Package，the top marking is shown as below:

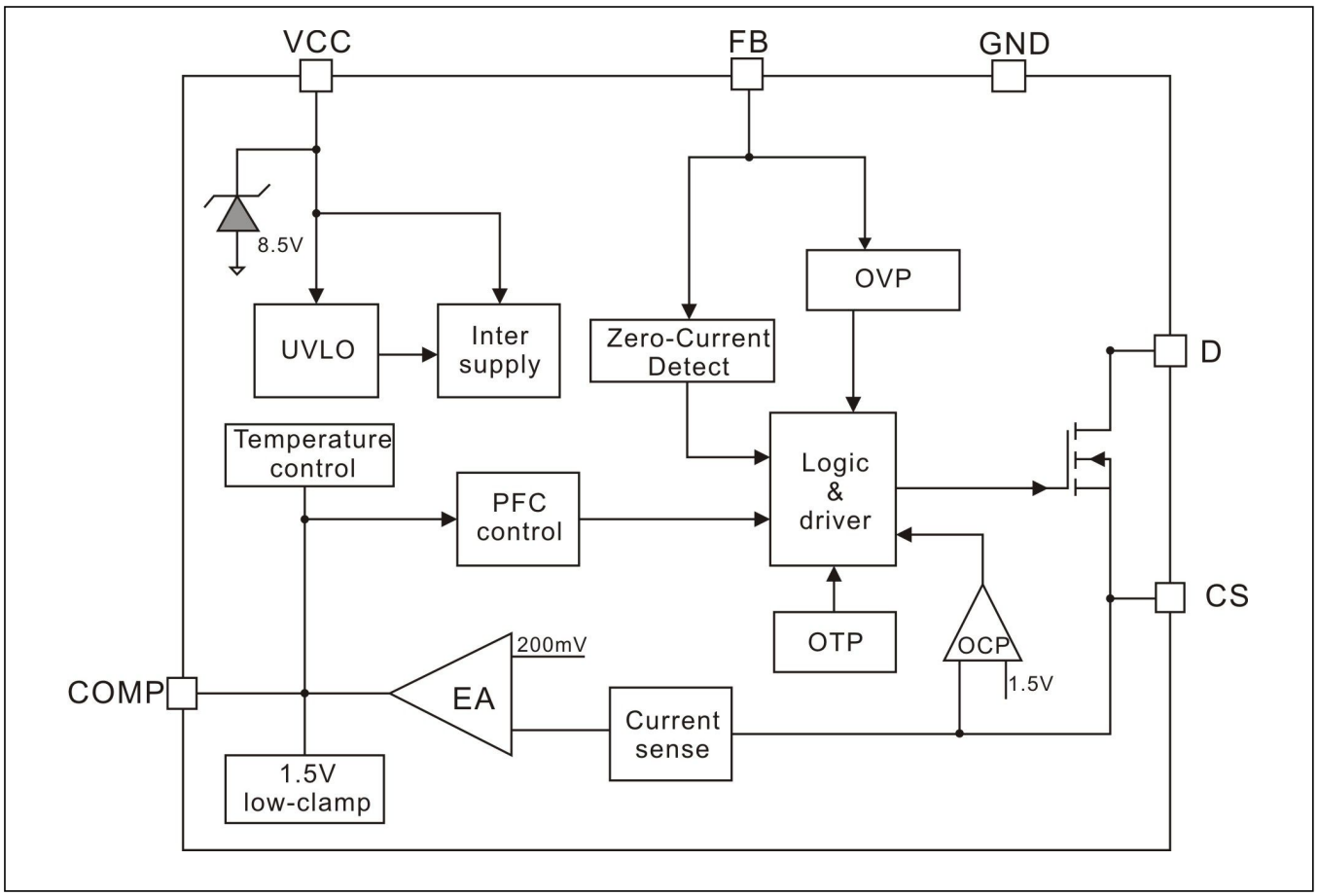


WS3412AHS7P
A：Product Code
X：Internal Code
BCY：Internal Code For QC
YMX：D/C

Pin Definition

Name	Pin No.	Description
COMP	1	Loop Compensation Node. This pin connects a capacitor to GND for stabilization of the control loop, achieving accurate LED current, high Power Factor and low THD.
GND	2	Ground.
VCC	3	Power Supply Pin. Connect a bypass capacitor from this pin to GND.
FB	4	Feedback Voltage Input Pin. This pin detects the inductor demagnetization signal and the output voltage.
D	5/6	Internal HV Power MOSFET Drain.
CS	7	Current Sense Pin. Connect a resistor to GND to sense the inductor current.

Internal Block Diagram



Ordering Information

Package	Marking	Part Number
7-Pin SOP-7, Pb-free	WS3412AHS7P	WS3412AHS7P

Recommended Operation Conditions

Part Number	Package	Input voltage	Maximum output power
WS3412AHS7P	SOP7	175VAC-264VAC	120V/150mA
		90VAC-264VAC	72V/150mA

Absolute Maximum Ratings

symbol	paramete	Range	unit
V_{CC}	Vcc pin voltage	-0.3~8	V
V_D	Internal HV MOSFET Drain to Source voltage	-0.3-600	V
V_{CS}	Current sense pin input voltage	-0.3~7	V
V_{FB}	Feedback pin input voltage	-0.3~7	V
V_{COMP}	Compensation pin voltage	-0.3~7	V
P_{DMAX}	Power dissipation	0.5	W
T_J	Operating junction temperature	165	℃
T_{STG}	Storage temperature range	-55~165	℃

Note : Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device.

Electrical Characteristics (Unless otherwise specified, VCC=8V and TA =25 ℃)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage Section						
V_{cc_clamp}	VCC Clamp Voltage		7.5	8.0	8.5	V
I_{cc_clamp}	VCC Clamp Current			5		mA
V_{CC_ST}	VCC Turn On Threshold	VCC Rising	7.07	7.57	8.07	V
V_{uvlo_HYS}	VCC Turn Off hysteresis	VCC Falling		1.32		V
I_{st}	VCC Startup Current	VCC<VCC_ST-0.5V		70	100	uA
I_{op}	VCC Operating Current			400		uA
Current Sense Section						
Vocp	Over current Protectionthreshold			1.5		V
T_{LEB}	Leading Edge Blanking Time for Current Sense			350		ns
Td	Switch off Delay Time			200		ns
Compensation Section						
V_{REF}	Internal Reference Voltage		194	200	206	mV
V_{CL}	COMP Low Clamp Voltage			1.5		V
V_{CH}	COMP High Clamp Voltage			4		V
Internal driver						
T_{OFF_MIN}	Minimum Off Time			3		us
T_{ON_MAX}	Maximum On Time			40		us
Feedback Section						
V_{FB}	FB Over Voltage Protection Threshold			1.6		V
V_{ZCD}	FB Falling Edge Threshold Voltage			0.2		V
Power MOSFET						
R_{DSON}	Static Drain-source On-resistance			6.8	8.5	Ω
V_{DS}	Drain-Source Breakdown Voltage		600			V
Thermal Regulation Section						
T_{REG}	Thermal Regulation Temperature			150		℃

Application Information

The WS3412AH is a high precision Active PFC driver integrating 600V power MOSFET, specially designed for non-isolated buck offline constant current LED lighting. Operating in critical conduction mode, the driver achieves high power factor, low THD and high efficiency.

Start Up

After system powered up, the VCC pin capacitor is charged up by the start up resistor. When the VCC pin voltage reaches the turn on threshold, the internal circuits start working. The COMP pin voltage is pulled up to 1.5V quickly, then the WS3412AHstarts switching. The system works at 10k Hz frequency at the beginning, the COMP voltage rises up gradually, and the inductor peak current also rises up. The LED current hence achieves a soft start without overshoot. After the output voltage is built up, the VCC power is supplied by the output voltage through a diode.

The maximum value of the startup current is 100uA. For the application of 85VAC—264VAC, the startup resistor can be calculated by the equation:

$$R_{st} < \frac{V_{in_\min}}{I_{st_\max}} \approx \frac{85V}{100uA} = 850K\Omega$$

Constant Current Control

The WS3412AH utilizes floating ground structure. The inductor current is sensed during the whole switching cycle, thus it achieves high precision output current control and also excellent line and load regulation.

The current in LED can be calculated by the equation:

$$I_O = \frac{V_{CS}}{R_{CS}} = \frac{200mV}{Rcs}$$

Rcs is the current sensing resistor.

Feedback Network

The WS3412AH senses the output current zero crossing information through the feedback network, the FB falling threshold voltage is set to 0.2V with 0.15V hysteresis. The FB pin is also used to detect output OVP, the threshold voltage is 1.6V. The ratio of FB upper resistor to lower resistor can be set as:

$$\frac{R_{FBL}}{R_{FBL}+R_{FBH}} = \frac{1.6V}{V_{OVP}}$$

Where,

RFBL: The lower resistor of the feedback network

RFBH: The upper resistor of the feedback network

VOVP: Output over voltage setting point

The minimum VOVP should be set about 1.3Vo.It is recommended that the FB lower resistor is set to 3.3KΩ—5.1KΩparalleled with a 22pF ceramic capacitor.

Protection Functions

The WS3412AH offers rich protection functions to improve the system reliability.

When the LED is open circuit, the output voltage will gradually rise up. The output voltage is sensed by the FB pin when power MOSFET is turned off. When FB voltage reaches the OVP threshold, it will trigger fault logic and the system stops switching.

When the LED is shorted circuit, the system will work under 10k Hz switching frequency. Meanwhile, the output voltage is low and the VCC pin cannot be charged up by the output voltage, so the VCC pin voltage will gradually decrease and finally reaches the UVLO threshold.

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

When the output is short circuit or the inductor is saturated, the CS peak voltage will be relatively high. When CS voltage reaches the internal limitation (1V), the power MOSFET will be turned off instantaneously. This cycle by cycle current limitation can help protecting the power MOSFET, the inductor and the output diode.

Thermal Regulation

The WS3412AH integrates thermal regulation function. When the system is over temperature, the output current is gradually reduced; the output power and thermal dissipation are also reduced. The system temperature is regulated and the system reliability is improved. The thermal regulation temperature is set to 150℃ internally.

PCB Layouts

The following guidelines should be followed in WS3412AH 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 resistor should be short and wide, and it should be as close as possible to the IC ground (pin 2), otherwise the LED output current accuracy maybe affected. The IC signal ground for COMP and FB components should be connected to the IC GND pin with short traces and should be away from the power ground path.

The Area of Power Loop

The area of main current loop should be as small as possible to reduce EMI radiation.

FB Pin

The feedback resistor divider should be as close as possible to the FB pin, and the trace must keeps away from dynamic node of the inductor (DRAIN pin trace、the positive pin and the negative pin of Vo trace), otherwise the FB pin OVP function might have risk to be mis-triggered by the system noise.

DRAIN Pin

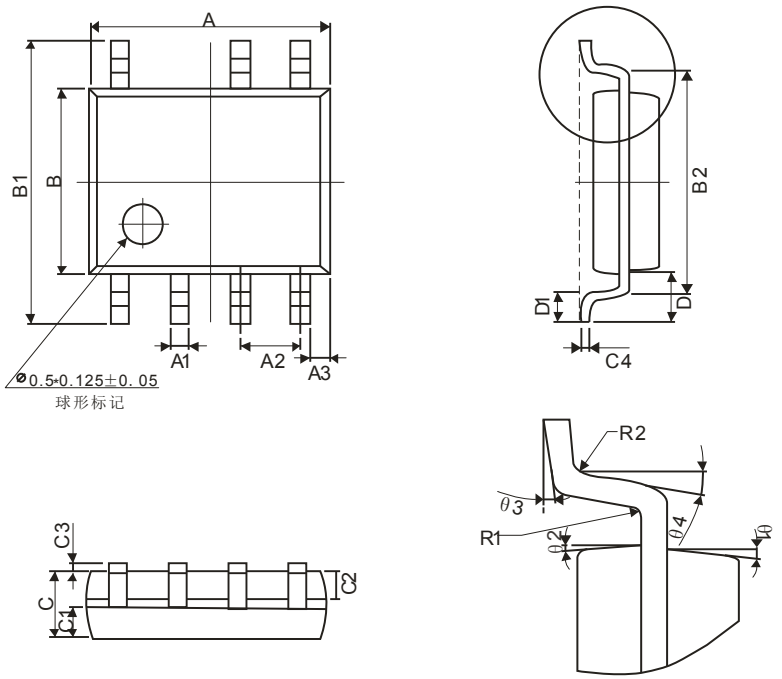
To increase the copper area of DRAIN pin for better thermal dissipation. However, too large copper area may compromise EMI performance.

The material of PCB

Avoid choosing the material that is easy to absorb the moisture, just like paper copper-clad laminates.

Package Information

SOP7Package Outline Dimensions



Symbol	Winsemi			
	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	4.70	5.10	0.185	0.201
B	3.70	4.10	0.146	0.161
C	1.30	1.50	0.051	0.059
A1	0.35	0.48	0.014	0.019
A2	1.27TYP		0.05TYP	
A3	0.345TYP		0.014TYP	
B1	5.80	6.20	0.228	0.244
B2	5.00TYP		0.197TYP	
C1	0.55	0.70	0.022	0.028
C2	0.55	0.70	0.022	0.028
C3	0.05	0.225	0.002	0.009
C4	0.203TYP		0.008TYP	
D	1.05TYP		0.041TYP	
D1	0.40	0.80	0.016	0.031

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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