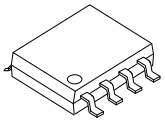
ISOLATED, PRIMARY SIDE CONTROL LED LIGHTING DRIVER WITH ACTIVE PFC



SOP-8

■ DESCRIPTION

The UTC **UPSL101** is a primary side control offline LED lighting controller which can achieve high power factor and accurate LED current for an isolate lighting application in a single converter.

The UTC **UPSL101** can control the LED current accurately from the primary side information. It can significantly simplify the LED lighting system design by eliminating the secondary side feedback components and the opto-coupler. And it integrates power factor correction function and works in transition mode for reducing the MOSFET switching losses.

The LED current can be adjusted externally by the sense resistor RCS at CS pin. The UTC **UPSL101** achieves high precision current along with excellent line regulation and load regulation.

The UTC **UPSL101** offers comprehensive protection coverage with auto-recovery features including V_{CC} over voltage protection, LED open/short circuit protection, over temperature protection, over current protection, leading edge blanking, V_{CC} under voltage lockout, V_{CC} clamp, GATE clamp, etc.

■ FEATURES

* Primary-side control with single stage PFC topology
* Transition mode (TM) operation to achieve high efficiency
* Minimized BOM count
* Cycle-by-cycle current limiting (OCP)
* Selectable threshold of OCP
* High current accuracy
* V_{CC} over voltage protection
* Analog multiplier for power factor correction
* Over-temperature protection
* Output over voltage protection
* LED open circuit protection
* LED short circuit protection
* Soft-start
* Ultra-low start-up current
* V_{CC} under voltage lockout (UVLO)

■ ORDERING INFORMATION

Ordering Number		Package	Packing
Lead Free	Halogen Free		
UPSL101L-S08-T	UPSL101G-S08-T	SOP-8	Tube
UPSL101L-S08-R	UPSL101G-S08-R	SOP-8	Tape Reel

Note: xx: Output Voltage, refer to Marking Information.

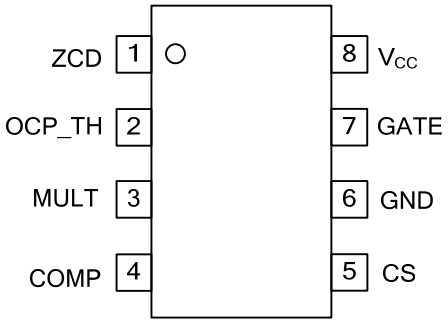
UPSL101L-xx-S08-R

(1)Packing Type
(2)Package Type
(3)Output Voltage Code
(4)Halogen Free

(1) R: Tape Reel, T: Tube
(2) S08: SOP-8
(3) xx: Refer to Marking Information
(4) G: Halogen Free, L: Lead Free

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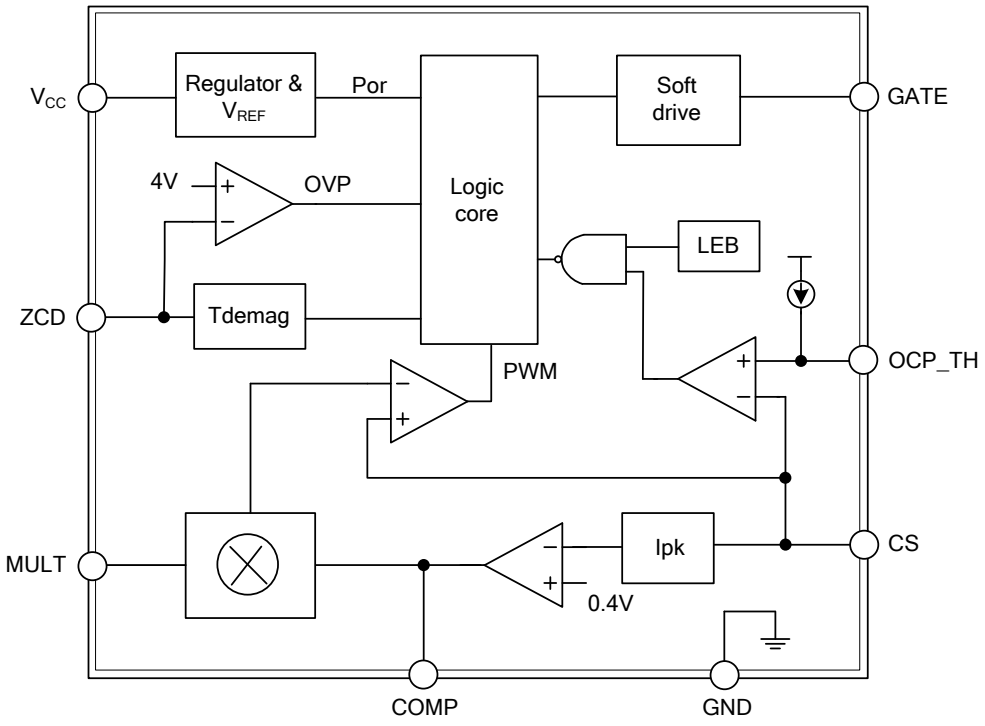
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	ZCD	Zero current detection pin. A negative going edge triggers the turn on signal of the external MOSFET, connected this pin through a resistor divider from the auxiliary winding to GND. If ZCD voltage is higher than the over voltage protection (OVP) threshold, the over voltage condition is detected.
2	OCP_TH	OCP threshold level selecting pin. Connected an external resistor to ground to select the OCP threshold voltage.
3	MULT	One of the input pin of the internal multiplier. Connected this pin to the tap of resister divider from the line voltage. The half waves sinusoid signal in this pin is provided a reference signal for the internal current control loop.
4	COMP	Loop compensation pin. Connect a compensation network to stabilize the LED driver and achieve a constant LED driver current.
5	CS	Current sense input pin. The MOSFET current is sensed via a resister.
6	GND	Ground pin.
7	GATE	Gate drive output pin.
8	V_{CC}	DC supply voltage pin.

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	RATINGS	UNIT
V_{CC} Input Voltage to GND		-0.3~30	V
GATE to GND		-0.3~30	V
I/O (Except GATE) to GND		-0.3~7	V
Operating Ambient Temperature	T_A	-20~85	°C
Junction Temperature	T_J	-40~150	°C
Storage Temperature	T_{STG}	-55~150	°C
Lead Temperature (10 Sec)	T_L	260	°C

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

■ RECOMMENDED OPERATING RANGE

PARAMETER	SYMBOL	RATINGS	UNIT
V_{CC} Voltage		11~25	V

■ ELECTRICAL CHARACTERISTICS (V_{CC}=16V, T_A=25°C, if not otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Voltage Section						
Standby Current	$I_V_{CC}_ST$	V_{CC}=14V		0.2	15	μA
Static Current	I_S_{TATIC}	V_{CC}=16V, No Switching		4.0	5.5	mA
V_{CC} Under Voltage Lockout Enter	$U_{VLO(ON)}$	V_{CC} Falling	7	8	9	V
V_{CC} Under Voltage Lockout Exit	$U_{VLO(OFF)}$	V_{CC} Rising	13.6	14.6	15.6	V
V_{CC} Clamp Protection	$V_{CC}_C_{LAMP}$			30		V
V_{CC} Over Voltage Protection	V_{CC}_OVP			28		V
Current Sense Section						
Lead Edge Blanking Time	T_L_{EB}			20		ns
OCP Propagation Delay	Td_OC	From OCP Comparator to Gate Drive		300		ns
Source Current of OCP_TH PIN	I_{OCP}_TH	V_{CC}=16V	27	38	49	μA
Threshold Voltage of Over Current Protection	$V_{TH}_O_{CP}$	0V<V_{OCP}_TH<0.3V		2.1		V
		0.3V<V_{OCP}_TH<1.5V		1.8		V
		V_{OCP_TH}>1.5V		1.5		V
Multiplier Section						
Linear Operating Range	V_{MULT}	C_{OMP}=3V	0~3			V
Output Max. Slope	$\Delta V_{CS}/\Delta V_{MULT}$	M_{ULT}=From 0 to 0.5V, C_{OMP}=4V		1.5		V/V
Gain	K	M_{ULT}=1V, C_{OMP}=2.2V	0.6	0.75	0.9	1/V
ZCD Section						
Output Over Voltage Protection	V_{OVP}	1μs Delay After Turn Off	3.8	4	4.2	V
ZCD Low Voltage Detection	$V_{ZCD}_L_{OW}$			0.9		V
When ZCD Rise up This Voltage, Demagnetization Began	$V_{TH}_D_{EM}_H$			0.9		V
When ZCD Drop Below This Voltage, Demagnetization Finished	$V_{TH}_D_{EM}_L$			0.12		V

■ ELECTRICAL CHARACTERISTICS (Cont.)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Gm amplifier section						
EA Reference Voltage	V_{REF}		394	400	406	mV
EA Transconductance Gain	G_M			100		μS
DC Gain	G_{AIN}		35	45		dB
Dynamic Range	V_{OUT}		1.2~4.5			V
Upper Clamp Voltage	V_{COMP}_H				6	V
Lower Clamp Voltage	V_{COMP}_L			1		V
EA Maximum Source Current	I_{SOURCE}_Max			100		μA
EA Maximum Sink Current	I_{SINK}_Max			35		μA
Watch Dog Section						
Re-start Timer Period	T_{OFF}_Max			50		μs
Minimum Off Time	T_{OFF}_ Min			2		μs
Maximum On Time	T_{ON}_Max			44		μs
OTP Section						
Over Temperature Protection	OTP_ON		120	140	160	°C
Gate Drive Output Section						
Output Low Level	V_{OL}	V_{CC}=16V @ I_{OUT}=100mA			2.5	V
Output High Level	V_{OH}	V_{CC}=16V @ I_{OUT}=100mA	8			V
Output Clamping Voltage	V_{CLAMP}	V_{CC}=28V			16	V
Rising Edge Time	T_R	C_L=1nF, 10~90%		30	150	nS
Falling Edge Time	T_F	C_L=1nF, 10~90%		20	70	nS

■ FUNCTION DESCRIPTION

The UTC **UPSL101** is a primary side control offline LED lighting controller which can achieve high power factor and accurate LED current for an isolate lighting application in a single converter. The UTC **UPSL101** can control the LED current accurately from the primary side information. It can significantly simplify the LED lighting system design by eliminating the secondary side feedback components and the opto-coupler. And it integrates power factor correction function and works in transition mode for reducing the MOSFET switching losses.

The principle of operation can be understood by referring to the block diagram.

Startup

The V_{CC} pin of UTC **UPSL101** is connected to the line input through a resistor. A large value startup resistor can be used to minimize the power loss in application because the start current of UTC **UPSL101** is very low. When the V_{CC} voltage reaches $U_{VLO(OFF)}$, the internal startup circuit is disabled and the IC turns on.

Operating Current

The operating current of UTC **UPSL101** is as low as 1.5mA. Good efficiency and very low standby power can be achieved.

Transition Mode Operation

During the external MOSFET on time, the rectified input voltage is applied across the primary side inductor and the primary current increases linearly from zero to the peak value. When the external MOSFET turns off, the energy stored in the inductor forces the secondary side diode to be turn on, and the current of the inductor begins to decrease linearly from the peak value to zero, this decreasing is also reflected on the auxiliary winding. UTC **UPSL101** performs zero current detection (ZCD) through ZCD pin by monitoring the voltage activity on the auxiliary windings in series with external resistors. When ZCD pin voltage falls below 0.3V, an internal ZCD comparator is triggered and generates the turn on signal of the external MOSFET.

LED Constant Current Regulation

The proprietary real current control method allows the UTC **UPSL101** controlling the secondary side LED current from the primary side information. The LED mean current can be calculated approximately as:

$$I_{LED} \approx \frac{N}{2} * \frac{Vref}{R_{CS}}$$

N-Turn ratio of primary side to secondary side

V_{REF}-The reference voltage (typical 0.4V)

R_{CS}-The sensing resistor connected between the MOSFET source and GND.

Current Sensing and Leading Edge Blanking

Cycle-by-cycle current limiting is offered in UTC **UPSL101**. The switch current is detected by a sense resistor into the CS pin. When the power switch is turned on, a turn-on spike will occur on this resistor. A leading-edge blanking is built in to avoid false-termination of the switching pulse so that the external RC filtering is no longer needed. PWM duty cycle is determined by the current sense voltage and the voltage at pin COMP.

Threshold of OCP Selection

The threshold voltage level of OCP is selected by the voltage of OCP_TH pin. The UTC **UPSL101** provides the source current equal to approximately 28μA through OCP_TH pin. So the proper resistor can be connected with the OCP_TH pin to GND in order to generate the voltage needed. If OCP_TH pin is connected with 33K resistor, the threshold voltage of OCP is about 1.8V; If OCP_TH pin is connected with 110K resistor, the threshold voltage of OCP is about 1.5V; If OCP_TH pin is connected with GND directly, the threshold voltage of OCP is about 2.1V.

Voltage of OCP_TH Pin	Connecting State of OCP_TH	Threshold Voltage of OCP
3V	110K	1.5V
0.9V	33K	1.8V
0V	GND	2.1V

Maximum and Minimum On-Time

The minimum on-time of the system is determined by the LEB time. The IC limits the on-time to a maximum time of approximately 50μs.

■ FUNCTION DESCRIPTION (Cont.)

Maximum Frequency Clamp

According to Transition Mode (TM) Operation principle, the switching frequency is inversely proportional to the output power. Therefore, when the output power decreases, the switching frequency can become rather high without limiting. The maximum switching frequency in UTC **UPSL101** is internally limited to approximately 300kHz.

Power Factor Correction

The MULT pin is connected to the tap of the resistor divider from the rectified instantaneous line voltage and fed as one input of the multiplier. The output of the multiplier will be shaped as sinusoid too. This signal provides the reference for the current comparator and comparing with the primary side inductor current which sets the primary peak current shaped as sinusoid with the input line voltage. High power factor can be achieved.

V_{CC} OVP and Clamping Protection

V_{CC} is supplied with transformer auxiliary winding output. It is clamped if V_{CC} exceeds 30V. When V_{CC} is higher than 28V, OVP protection is triggered and GATE is shut down, so the device enters power on startup sequence thereafter.

LED String Short Protection

When LED string is short, the positive plateau of auxiliary winding voltage is also near zero and the ZCD voltage is low. If the voltage at ZCD pin is lower than a threshold of approximately 0.9V and lasts more than 10ms, the IC will shut down.

LED String Open Protection

When the LED string open circuit happens, the positive plateau of auxiliary winding voltage increases and the ZCD voltage is high. If the voltage at ZCD pin is higher than a threshold of approximately 4V, UTC **UPSL101** will shut down and restart again.

Thermal Shutdown

UTC **UPSL101** provides an on chip thermal shutdown. The IC will stop switching when the junction temperature exceeds the thermal shutdown temperature, typically 140°C.

Gate Drive Output

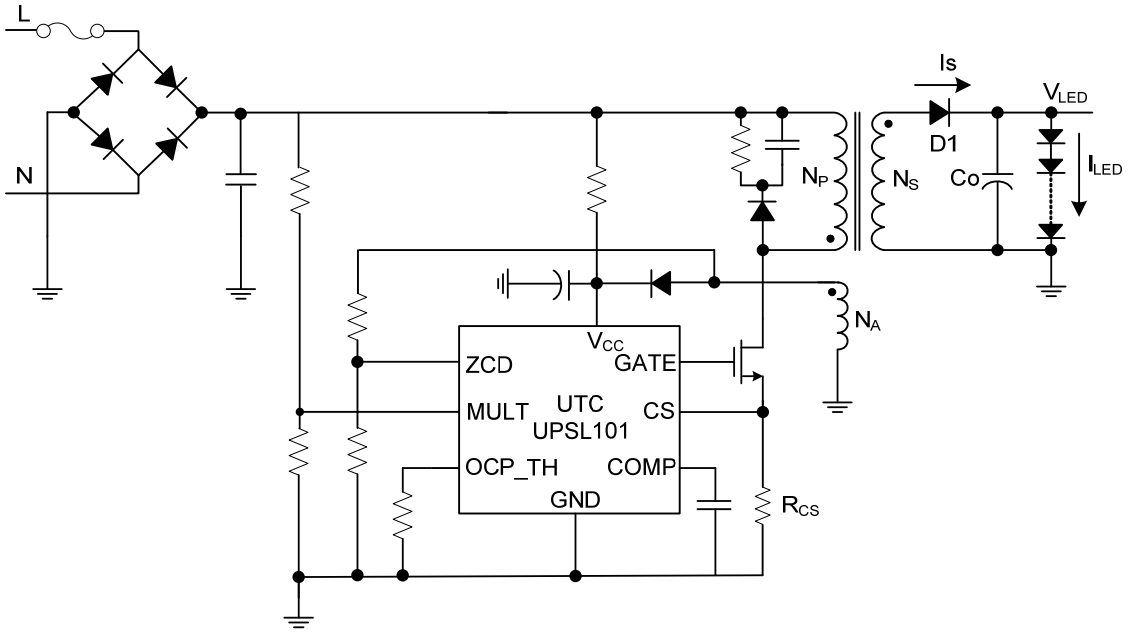
The UTC **UPSL101** output stage is a fast totem-pole gate driver. Cross conduction has been avoided to minimize heat dissipation, increase efficiency, and enhance reliability. The output driver is clamped at 12V to protect power MOSFET transistors against undesired over-voltage gate signals.

Protection Control

The UTC **UPSL101** offers comprehensive protection coverage with auto-recovery features including V_{CC} over voltage protection, LED open/short circuit protection, over temperature protection, over current protection, leading edge blanking, V_{CC} under voltage lockout, V_{CC} clamp, GATE clamp, etc.

V_{CC} is supplied by transformer auxiliary winding output. The output of UTC **UPSL101** is shutdown when V_{CC} drops below UVLO (ON) and the power converter enters power on start-up sequence thereafter.

■ TYPICAL APPLICATION CIRCUIT



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