Applications Note:SY58761

Single Stage Boost PFC LED Driver
Dimmable, High PF and Low BOM Cost

General Description

SY58761 is a single-stage Boost PFC driver for LED lighting applications. Good compatibility is achieved with Leading/Trailing edge dimmer and high PF is achieved without any dimmer.

SY58761 drives the converter in Quasi-Resonant mode to achieve high efficiency. Reliable Open LED protections are integrated.

SY58761 integrates high voltage power FET inside to save driver space further.

SY58761 is available in SOT23-5 package.

Ordering Information

SY58761 □(□ □)□
- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package type	Note
SY58761AAC	SOT23-5	----

Features

- Compatible with Leading Edge/Trailing Edge Dimmer
- High PF without Any Dimmer
- 350V MOSFET Integrated
- Quasi-Resonant Operation
- Reliable Open LED Protection
- Thermal Fold Back
- Low BOM Cost
- Compact Package: SOT23-5

Applications

- LED Lighting
- Leading Edge Dimming
- Trailing Edge Dimming

Typical Applications

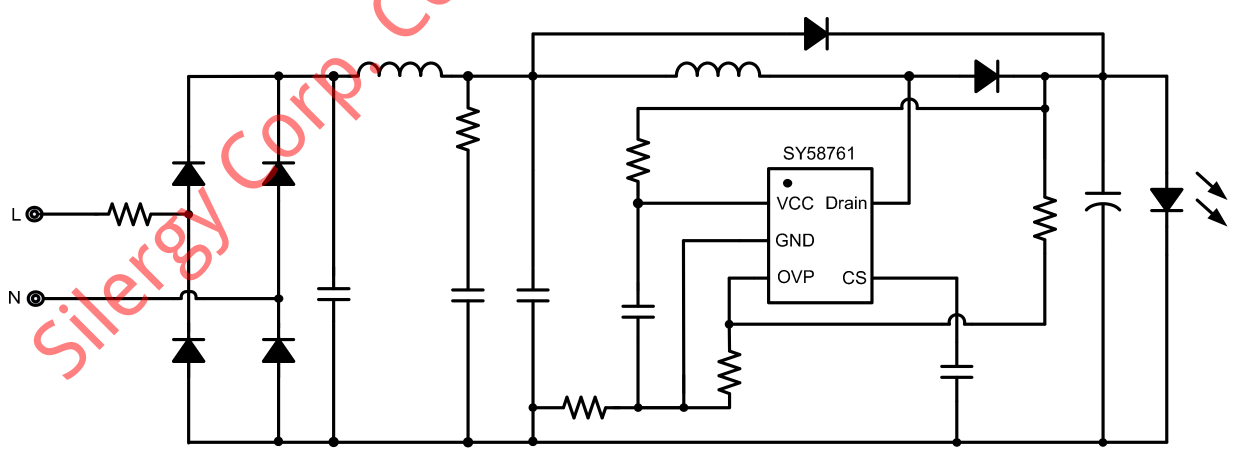
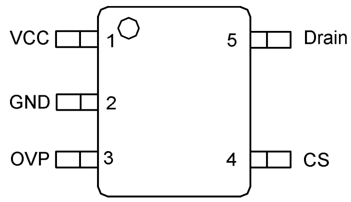


Figure 1. Typical application

Pinout (top view)



(SOT23-5)

Top Mark: *Zrxyz* (device code: Zr, ***x=year code, y=week code, z= lot number code***)

Pin Name	PIN Number	Pin Description
VCC	1	Bias supply pin.
GND	2	Ground pin.
OVP	3	Voltage sense pin. Connect to a resistor divider of inductor or auxiliary winding to sense output voltage. $V_{OVP}=K\times V_{OVP,REF}$, where K is the OVP resistor ratio coefficient.
CS	4	Current sense pin, connect a cap and sense res to GND pin. $R_{CS}=\frac{V_{REF}}{2I_O}$
Drain	5	Internal MOSFET drain node.

Block Diagram

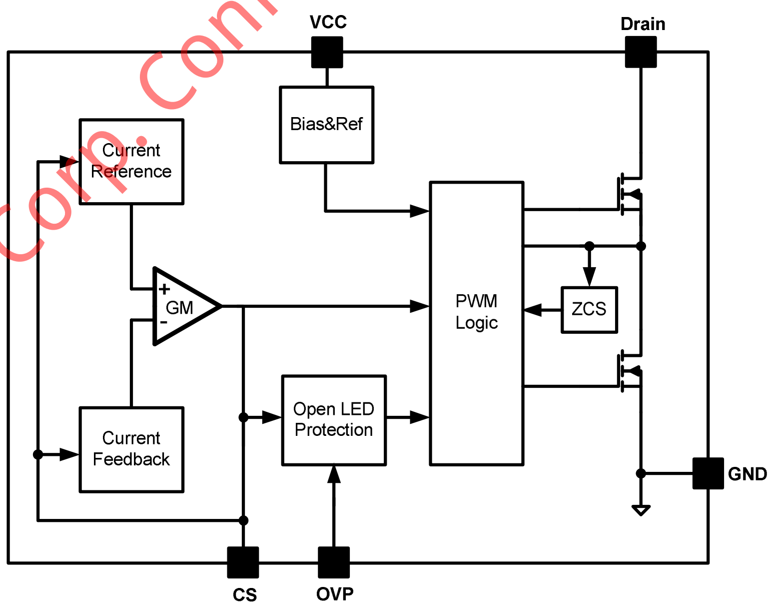


Fig.2 Simplified block diagram

Absolute Maximum Ratings (Note 1)

VCC -- -0.3V~20V
Ivcc -- 4mA
CS, OVP --- -0.3V~4V
Drain --- 350V
Maximum Junction Temperature -- 165°C
Lead Temperature (Soldering, 10 sec.) --- 260°C
Storage Temperature Range -- -65°C to 165°C

Electrical Characteristics

(V_{VCC} = 12V, T_A = 25°C unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supply Section						
VCC Turn-on Threshold	V_{VCC_ON}			14		V
VCC Turn-off Threshold	V_{VCC_OFF}			7		V
VCC Shunt Voltage	V_{VCC_Shunt}			14.5		V
Start up Current	I_{ST}			40		µA
Quiescent Current	I_Q			250		µA
CS pin Section						
Current Reference	V_{REF}			216		mV
CS Limit	V_{CS_MAX}			1.65		V
OVP Pin Section						
OVP Voltage Reference	$V_{OVP,REF}$			1.2		V
Driver Section						
Min ON Time	t_{ON_MIN}			500		ns
Max ON Time	t_{ON_MAX}			10		µs
Min OFF Time	t_{OFF_MIN}			1.5		µs
Max OFF Time	t_{OFF_MAX}			250		µs
Integrated MOSFET Section						
BV of HV MOSFET	V_{BV}		350			V
HV MOS Drain Source Resistance	R_{DSON_H}			4.2		Ω
Thermal Section						
Thermal Fold Back Temperature	T_{FB}			160		ºC
Thermal Shut Down Temperature	T_{SD}			T_{FB} +5		ºC

Note 1: Stresses beyond the "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 operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Test condition: Device mounted on 2" x 2" FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane

Note 3: The device is not guaranteed to function outside its operating conditions.

Operation

SY58761 is a single stage Boost PFC regulator targeting at LED lighting applications.

It is mainly used in mains dimming application and has good compatibility with Leading/Trailing edge dimmer.

In order to reduce the switching losses and improve EMI performance, Quasi-Resonant switching mode is applied, which means to turn on the power MOSFET at the valley of drain voltage.

It also provides reliable open LED protections and over temperature protection.

The IC is available with SOT-23 package.

Applications Information

Start up

After AC supply is powered on, the capacitor C_{VCC} between VCC and GND pin is charged up by output voltage (peak value of input voltage at the first of power on). Once V_{VCC} rises up to V_{VCC_ON}, the internal blocks start to work and V_{CS} is pre-charged to certain value.

The whole start up procedure is divided into three sections as shown below. t_{ST1} is the C_{VCC} charged up time. t_{ST2} is the time V_{CS} is charged up to certain value. t_{ST3} is the time IC works at steady state. Usually t_{ST2} is much smaller than t_{ST1}.

If bias supply has more power than IC consumption, V_{VCC} is greater than V_{VCC_Shunt}, and then a shunt current starts to work.

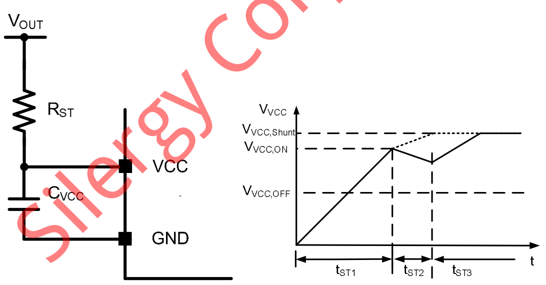


Fig.3 Start up

The start up component R_{ST} and C_{VCC} are designed as below:

(a) Set start-up resistor R_{ST}, make sure that the operation current is enough through R_{ST}. The worst case occurs at minimum input voltage, because after start up, the bias supply current is from V_{OUT} which is higher than peak value of input voltage.

$$R_{ST} < \frac{\sqrt{2}V_{AC,MIN}}{I_Q}$$

Where V_{AC_MIN} is the RMS value of minimum AC input voltage, I_Q is the operation current.

(b) Select C_{VCC} to obtain an ideal start up time t_{ST}, and to make sure that the $V_{VCC}>V_{VCC\_OFF}$ in t_{ST2}.
The recommended formula is as below:

$$C_{VCC} = \frac{(\frac{\sqrt{2}V_{AC,MIN}}{R_{ST}} - I_{ST}) \times t_{ST}}{V_{VCC\_ON}}$$

Where I_{ST} is the start up current. V_{VCC_ON} is the start up voltage of internal circuit.

Shut down

After AC supply is powered off, the energy stored in the output capacitor is discharged. When power supply for IC is not enough, V_{VCC} drops down. Once V_{VCC} is below V_{VCC_OFF}, the IC stops working.

LED current setting

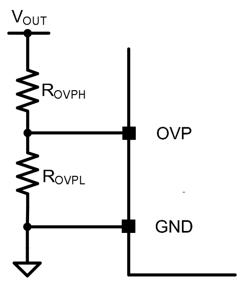
LED current is set by the resistor R_{CS}. The formula to program I_{LED} is as below:

$$I_{LED} = \frac{V_{REF}}{2 \times R_{CS}}$$

Where V_{REF} is the reference voltage.

Open LED protection

The protection voltage V_{OVP} for open LED is set by the resistor divider shown as below,



Then V_{OVP} is set by the formula,

$$V_{OVP} = \frac{R_{OVPH} + R_{OVPL}}{R_{OVPL}} V_{OVP,REF}$$

Where V_{OVP_REF} is 1.2V. When OVP triggers, Switching stops and VCC is pulled down until V_{VCC_OFF}, then IC starts up again and works in hiccup mode.

Thermal protection

Thermal fold back is adopted in this IC. Thermal fold back curve is shown as below.

When the junction temperature rises too high, internal current reference decreases first; if the junction temperature still rises up over T_{SD}, IC will be shut down.

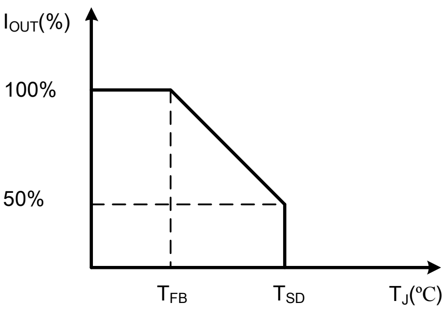


Fig.4 Thermal fold back curve

Power Device Design

MOSFET and Diode

When the operation condition is with maximum output voltage, the voltage stress of MOSFET and output power diode is maximized. MOSFET is integrated with 350V BV.

$$V_{DS\_MAX} = V_{OUT\_MAX}$$

Inductor (L)

The system operates in the peak current mode. The ON time increases with the input voltage decreasing. When the ON time reaches T_{ON_MAX}, the ON time is limit by T_{ON_MAX}.

The input voltage and inductor current waveforms are shown as below, where θ_1 and θ_2 are the first time and last time that inductor current touches the limit in each half line cycle. V_{IN1} is the instantaneous value of input voltage at θ_1 and θ_2.

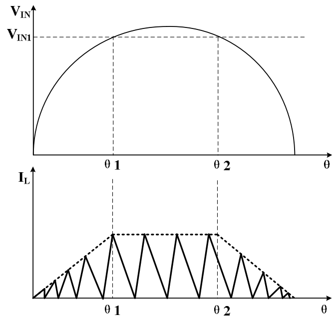


Fig.5 Input and output waveforms

In Quasi-Resonant mode, each switching period t_S consists of three parts: inductor current rising time t_1, falling time t_2 and quasi-resonant time t_3.

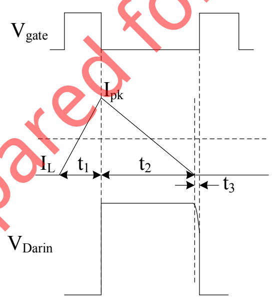


Fig.6 switching waveforms

The switching frequency is designed in rated input voltage considering conducted EMI test. Once the switching frequency f_{SW} is set, the inductance of the inductor could be calculated.

The design flow is shown as below:

(a) Preset frequency f_{SW} at peak value of rated input voltage

(b) Compute relative t_S, t_1

$$t_S = \frac{1}{f_{SW}}$$

$$t_1 = \frac{t_S \times (V_{OUT} - \sqrt{2} V_{AC\_RMS})}{V_{OUT}}$$

$$t_2 = t_S - t_1$$

Where V_{AC_RMS} is the RMS value of rated input voltage.

(c) Compute the peak current of inductor I_{PK}.

$$V_{IN1} = \sqrt{2}V_{AC\_RMS}\frac{t_1}{t_{ON,MAX}}$$

$$\theta_1 = \arcsin\left(\frac{V_{IN1}}{\sqrt{2}V_{AC\_RMS}}\right)$$

$$I_{PK} \approx \frac{I_{OUT}\cdot V_{OUT}\cdot \pi}{\sqrt{2}V_{AC\_RMS}\cdot\cos(\theta 1)\cdot\lambda}$$

Where V_{OUT} is the rated output voltage, I_{OUT} is rated output current. t_{ON_MAX} is maximum conducting time. λ is a coefficient that indicate the effect of negative resonant current and boost converter efficiency, and typically value is 0.8~0.9.

(d) Design inductance L

$$L = \frac{\sqrt{2}V_{AC\_RMS}\times t_1}{I_{PK}}$$

Inductor design (N)

Necessary parameters:	
Inductance	L
Io program resistor	R_{CS}
Current low limit voltage	$V_{CS,MIN}$

V_{CS_MIN} is 500mV, The design rules are as followed:

(a) Select the magnetic core type, identify the effective area A_e.

(b) Preset the maximum magnetic flux ΔB.
For PC40, ΔB selected to be 0.3~0.33T.

(c) Compute inductor maximum peak current $I_{L\_PK\_MAX}$ and maximum RMS current $I_{L\_RMS\_MAX}$.

$$I_{L\_PK\_MAX} = \frac{V_{CS\_MAX} - V_{CS\_MIN}}{R_{CS}}$$

$$I_{L\_RMS\_MAX} = \frac{1}{\sqrt{3}}I_{L\_PK\_MAX}$$

(d) Compute turn N

$$N = \frac{L}{\Delta B\times A_e}\times I_{L\_PK\_MAX}$$

(e) Select an appropriate wire diameter with $I_{L\_RMS\_MAX}$, select appropriate wire to make sure the current density ranges from $4A/mm^2$ to $10A/mm^2$.

(f) If the winding area of the core and bobbin is not enough, reselect the core style, go to **(a)** and redesign the inductor until the ideal inductor is achieved.

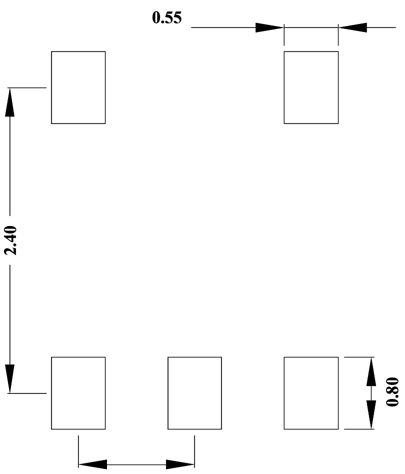
Output capacitor C_{OUT}

Choose proper output capacitance to satisfy current ripple. Output current ripple is set to ΔI_O, then,

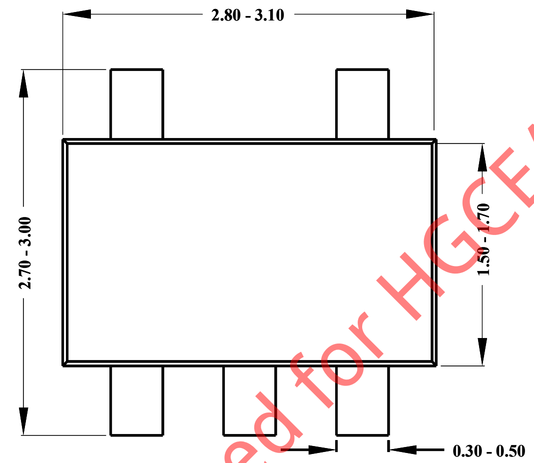
$$C_{OUT} = \frac{\sqrt{\left(\frac{2I_{OUT}}{\Delta I_O}\right)^2 - 1}}{4\pi\times R_{LED}\times f_{AC}}$$

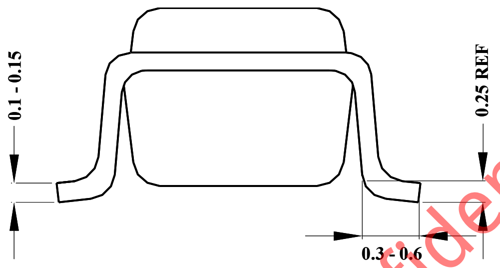
Where f_{AC} is the AC supply frequency; R_{LED} is the equivalent series resistor of LED load.

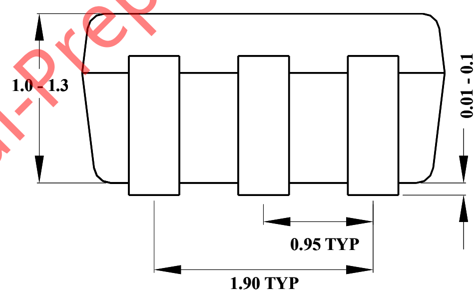
SOT23-5 Package outline & PCB layout design



Recommended Pad Layout



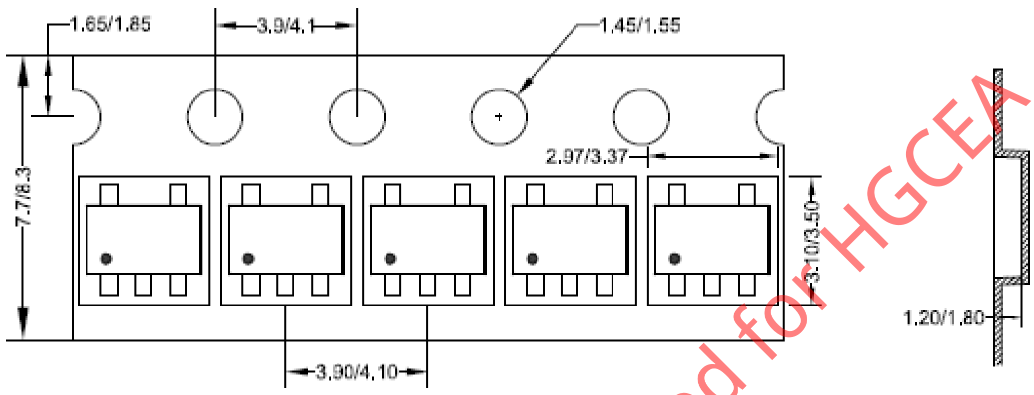




Notes: All dimensions are in millimeters.
All dimensions don't include mold flash & metal burr.

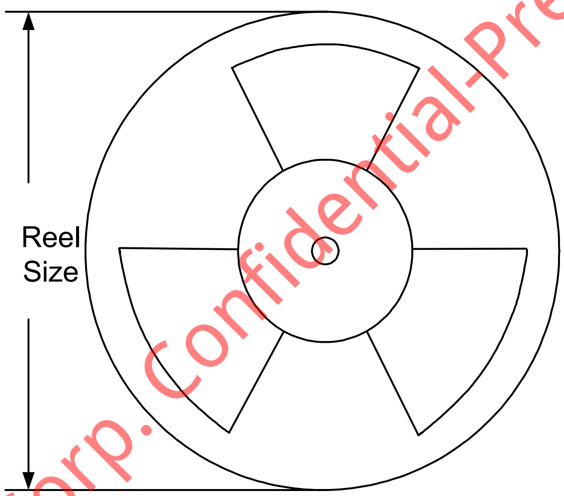
Taping & Reel Specification

1. Taping orientation for packages（SOT23-5）



Feeding direction →

2. Carrier Tape & Reel specification for packages



Package type	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
SOT23-5	8	4	7"	280	160	3000

单击下面可查看定价，库存，交付和生命周期等信息

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