Application Note: AN_SY8722

High Efficiency, Flicker-free MR16 LED Driver

Preliminary Specification

General Description

SY8722 is a high efficiency, flicker-free, MR16 LED driver which is powered by electronic transformer. The device integrates two DC/DC regulators. The first stage boosts the input voltage to a setting value and provides power supply for the second stage. The second stage regulates the LED current to the target value. With proprietary control scheme, the LED driver is compatible with most of commonly used electronic transformers. The high switching frequency allows the use of small size inductor and capacitor. The integrated low $R_{DS(ON)}$ MOSFETs reduce the power loss. Along with compact SO8E package, SY8722 provides ideal solution for MR16 LED lighting.

Ordering Information

SY8722 □(□□)□

- □ (last) — Temperature Code
- □□ — Package Code
- □ (first) — Optional Spec Code

Temperature Range: -40°C to 85°C

Ordering Number	Package type	Note
SY8722FCC	SO8E	--

Features

- Wide input range: 4-30V
- 200mΩ internal low $R_{DS(ON)}$ MOSFETs
- Fixed switching frequency:
  - CH1: 800kHz
  - CH2: 1MHz
- Flicker Free
- Compatible with most of electronic transformer
- RoHS Compliant and Halogen Free
- Compact package: SO8E

Applications

- MR16

Typical Applications

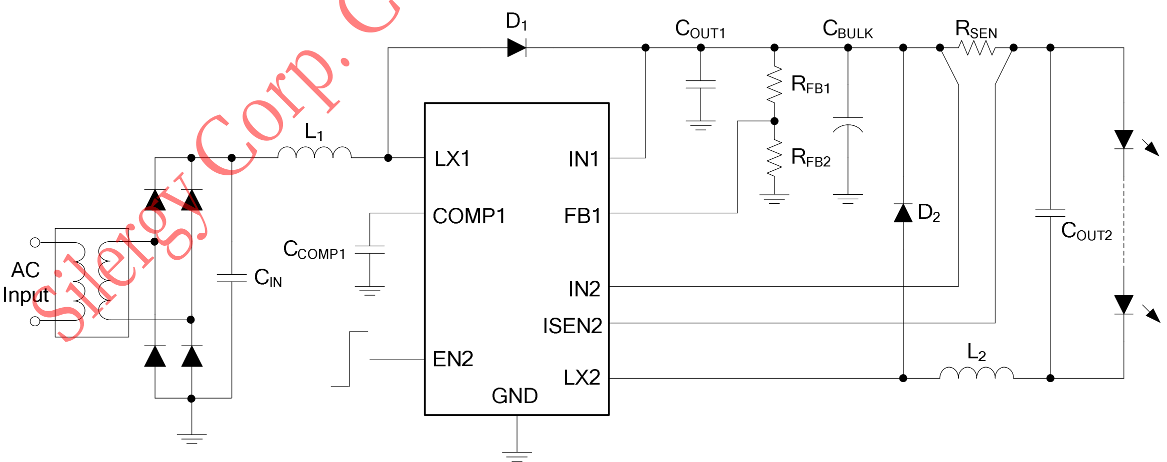
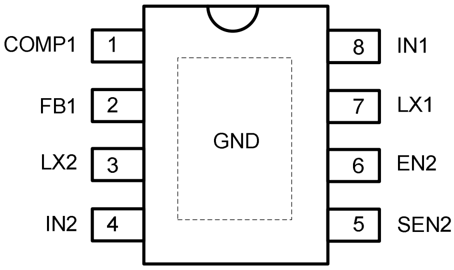


Figure 1. Schematic Diagram

Pinout (top view)



(SO8E)

Top Mark: **AIS*xyz*, (**Device code: AIS, ***x=year code, y=week code, z= lot number code*****)**

Pin Name	Pin Number	Pin Description
COMP1	1	Compensation pin for CH1. Connect a capacitor from this pin to GND
FB1	2	Feedback input and OVP input for CH1. The output voltage is within $1.0*(R_{FB1}+R_{FB2})/R_{FB2}$ to $1.2*(R_{FB1}+R_{FB2})/R_{FB2}$
LX2	3	Inductor node of CH2. Connect the switching node of the inductor to this pin.
IN2	4	Power supply input of CH2, also used as positive current sensing input
SEN2	5	Negative current sensing input of CH2. $I_{LED}(A) = \frac{0.1(V)}{R_{SEN}(\Omega)}$
EN2	6	Enable control. Pull high to turn on CH2. Do not float. This pin can also be used as dimming control. Apply a low frequency (<1kHz) PWM signal for PWM dimming and a high frequency (>20kHz) PWM signal for analog dimming.
LX1	7	Inductor node of CH1. Connect an inductor between power input and LX1 pin.
IN1	8	Power supply input of CH1
GND	Exposed Paddle	Ground pin

Absolute Maximum Ratings (Note 1)

IN1, IN2, LX1, LX2, EN2 -- 36V
COMP1, FB1 -- 3.6V
SEN2 -- V_{IN2}±0.7V
Power Dissipation, P_D @ T_A = 25°C, SO8E -- 3.3W
Package Thermal Resistance (Note 2)
SO8E, θ_{JA} -- 30°C/W
SO8E, θ_{JC} -- 10°C/W
Junction Temperature Range -- 125°C
Lead Temperature (Soldering, 10 sec.) -- 260°C
Storage Temperature Range -- -65°C to 150°C

Recommended Operating Conditions (Note 3)

IN1 -- 4V to 30V
Junction Temperature Range -- -40°C to 125°C
Ambient Temperature Range -- -40°C to 85°C

Electrical Characteristics

($V_{IN1} = V_{IN2} = 12V$, $T_A = 25°C$ unless otherwise specified)

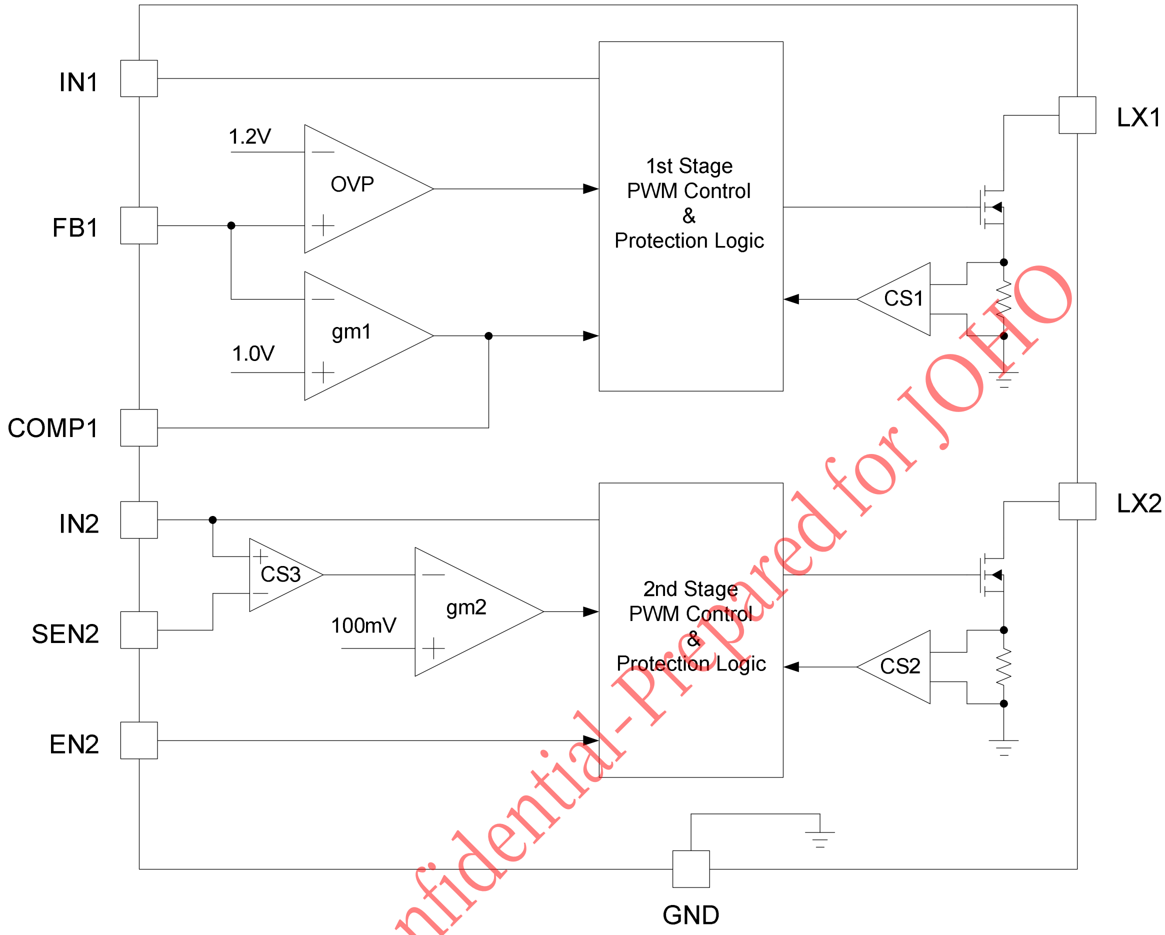
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN1}, V_{IN2}		4		30	V
CH1 Low Side Main FET RON	$R_{DS(ON)1}$			200		mΩ
CH2 Low Side Main FET RON	$R_{DS(ON)2}$			200		mΩ
CH1 Main FET Current Clamping Low Level	$I_{CLMP, LOW}$	Duty=0		1.5		A
CH1 Main FET Current Limit	I_{LIM1}	Duty=0		3		A
CH2 Main FET Current Limit	I_{LIM2}	Duty=0	2		3	A
CH1 Switching Frequency	Fsw1			800		KHz
CH2 Switching Frequency	Fsw2			1		MHz
Input UVLO Rising Threshold	$V_{IN,UVLO}$				3.9	V
Input UVLO Hysteresis	$U_{VLO,HYS}$			0.2		V
FB1 Reference Voltage	V_{REF1}		0.97	1.0	1.03	V
CH2 Current Sense Limit	V_{IN2}-V_{SEN2}		96	100	104	mV
CH1 OVP Rising Threshold	$V_{FB1,OVP}$			1.2		V
CH1 OVP Hysteresis	$V_{FB1,HYS}$			150		mV
Thermal Shutdown Temperature	T_{SD}			150		°C

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.

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

Block Diagram

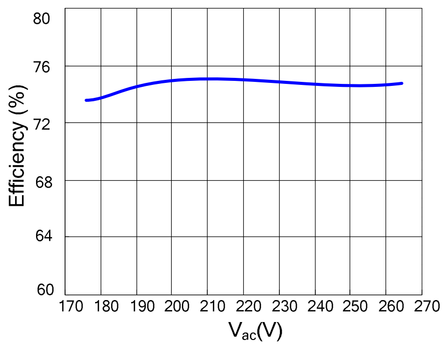


Typical Operating Characteristics

(176V~264V AC input, tested with ET-E60 electronic transformer)

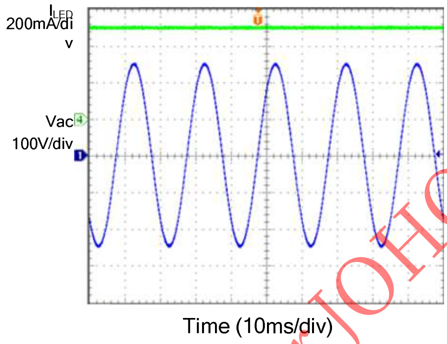
Efficiency vs. Input Voltage

(I_{LED}=0.5A, 3pcs LED)



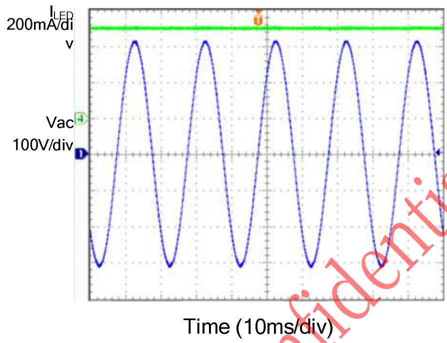
LED Current

(Vac=176V,I_LED=500mA,3pcs LED)



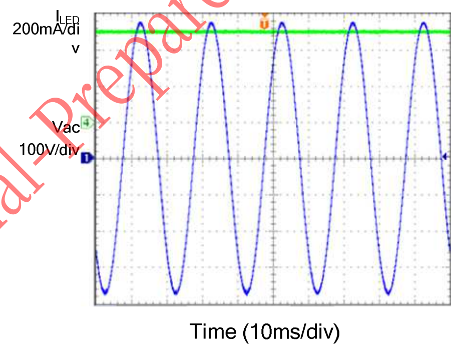
LED Current

(Vac=220V,I_LED=500mA,3pcs LED)



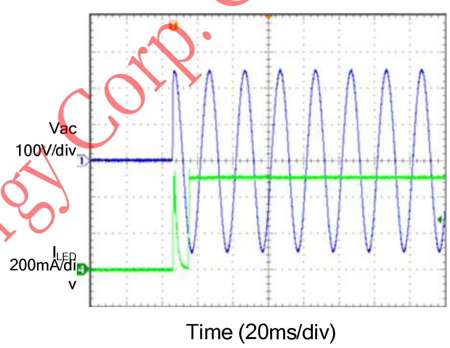
LED Current

(Vac=264V,I_LED=500mA,3pcs LED)



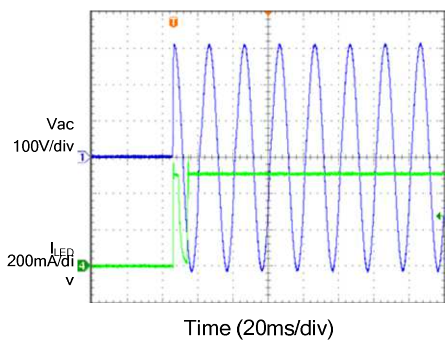
Power Up

(Vac=176V,I_LED=500mA,3pcs LED)



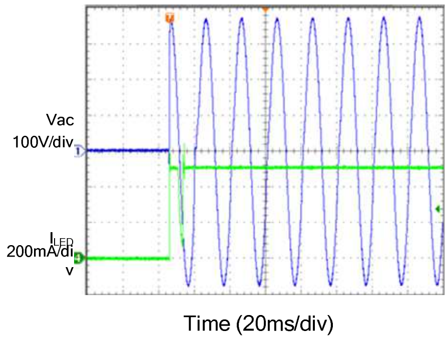
Power Up

(Vac=220V,I_LED=500mA,3pcs LED)



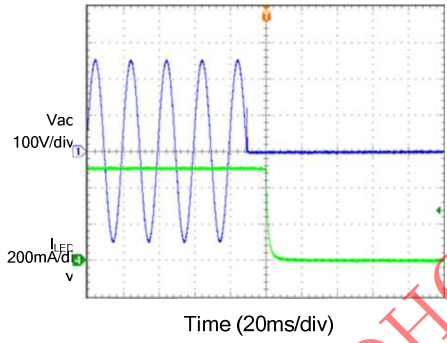
Power Up

(Vac=264V,I_LED=500mA,3pcs LED)



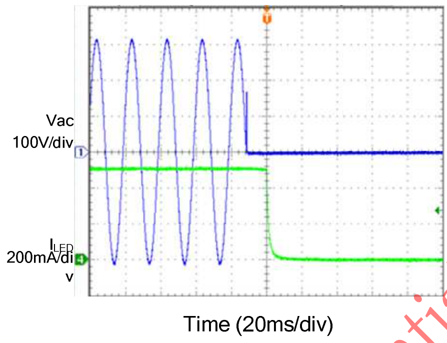
Power Down

(Vac=176V,I_LED=500mA,3pcs LED)



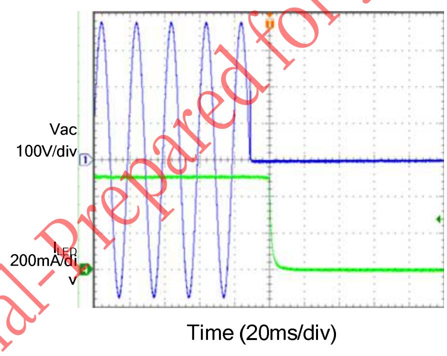
Power Down

(Vac=220V,I_LED=500mA,3pcs LED)



Power Down

(Vac=264V,I_LED=500mA,3pcs LED)



Operation

SY8722 contains a Boost voltage regulator, and a floating Buck current regulator. The voltage regulator regulates the input to a setting voltage and provides power supply for the current regulator, while the current regulator provides constant current for LED loads.
With integrated ultra low $R_{DS(ON)}$ power switches and proprietary PWM control, this regulator IC can achieve the high efficiency and the high switch frequency simultaneously to minimize the external inductor and capacitor size, and thus achieving the minimum solution footprint.

Applications Information

Because of the high integration of SY8722 IC, the application circuit based on this IC is relatively simple. Only several external components are required.

Feedback resistor divider R_{FB1}, and R_{FB2},:
Choose R_{FB1} and R_{FB2} to program the minimum output voltage of the Boost regulator. To minimize the power consumption, it is desirable to choose large resistance values for both R_{FB1} and R_{FB2}. A value of between 10kΩ and 1MΩ is highly recommended for both resistors.
If R_{FB2}=13.7k is chosen, then R_{FB1} can be calculated to be:

$$R_{FB1} = R_{FB2} \times (V_{BUS\_MIN} - 1)$$

V_{BUS_MIN} is the minimum output voltage of Boost regulator. It should be higher than the maximum input.
Once R_{FB1} and R_{FB2} are chosen, the maximum output voltage of the Boost regulator is its OVP voltage that can be calculated to be:

$$V_{BUS\_OVP} = 1.2 \times (\frac{R_{FB2}}{R_{FB1}} + 1)$$

Current sense resistor R_{SEN}:
Choose R_{SEN} to program the proper output current for the Buck regulator:

$$I_{LED}(A) = \frac{0.1(V)}{R_{SEN}(\Omega)}$$

Output capacitor C_{OUT1}, C_{OUT2} and C_{BULK},:
The output capacitor C_{OUT1} and C_{OUT2} are selected to handle the output ripple noise requirements. For the best performance, it is recommended to use X5R or better grade ceramic capacitor greater than 1uF capacitance. C_{OUT1} is use to handle both output ripple of Boost regulator and input ripple of Buck regulator, the RMS current through the capacitor is relatively high. The RMS current rating of the capacitor should be considered.
The bulk capacitor is used to hold the bus voltage when the electronic transformer has no output. For most applications, it is recommended to use an aluminum electrolytic capacitor with greater than 220uF capacitance.

Compensation capacitor C_{COMP},:
In applications powered by electronic transformer, the input voltage can change roughly in one cycle of AC power frequency. A 1uF ceramic capacitor connected from COMP1 pin to ground help to stabilize the control loop of the Boost regulator.

Output inductor L_1 and L_2:
With propriety control scheme, the Boost regulator is quit tolerant with difference inductance. For better efficiency and input power factor, it is suggested the inductance of L_1 is around the value of output power, and the current rating should be higher than 2A.
For the Buck regulator, it is suggested to choose the ripple current to be about 40% of the maximum average inductor current. The inductance is calculated as:

$$L_2 = \frac{V_{LED}(1 - V_{LED}/V_{BUS\_OVP})}{F_{SW2} \times I_{LED} \times 40\%}$$

Where Fsw2 is the switching frequency of Buck regulator and I_{LED} is the LED current.
The saturation current rating of L_2 must be selected to be greater than the peak inductor current under full load conditions.

$$I_{SAT} > I_{LED} + \frac{V_{LED}(1 - V_{LED}/V_{BUS\_OVP})}{2 \cdot F_{SW2} \cdot L_2}$$

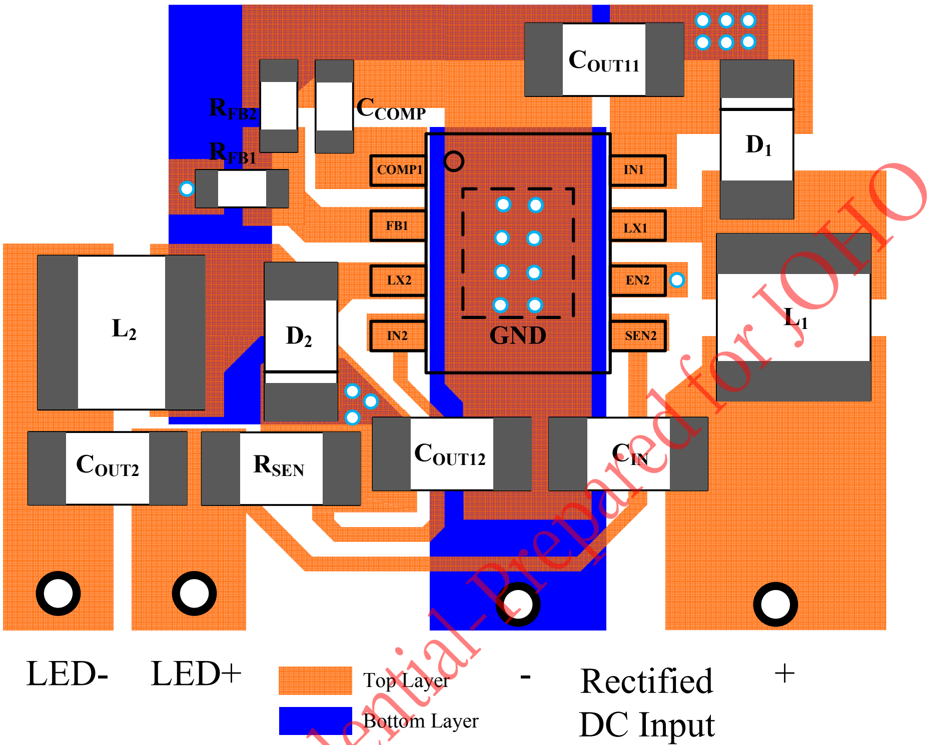
Layout Design:
The layout design of SY8722 regulator is relatively simple. For the best efficiency and minimum noise problems, we should place the following components close to the IC: C_{IN}, L_1, L_2, D_1, D_2, C_{OUT1}, C_{OUT2} and R_{SEN}.

1) It is desirable to maximize the PCB copper area connecting to GND pin to achieve the best thermal and noise performance. If the board space allowed, a ground plane is highly desirable.

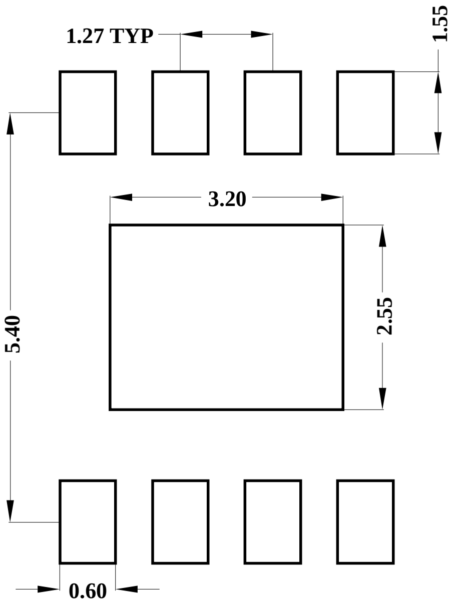
2) Use two pieces of MLCC for C_{OUT1}. Minimize the loop area formed by D_1, C_{OUT11}, LX1 and GND, and loop area formed by D_2, C_{OUT112}, LX2 and GND

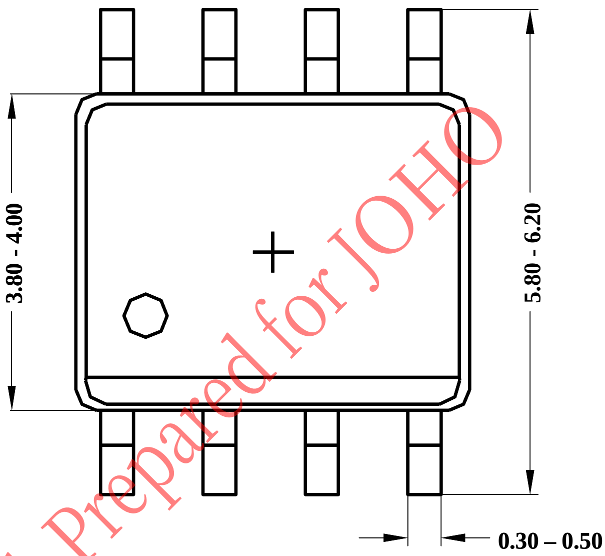
3) Apply Kelvin sense on R_{SEN} for accurate LED current control

4) The PCB copper area associated with LX pin must be minimized to avoid the potential noise problem.

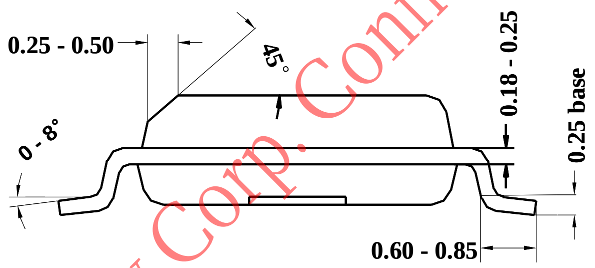


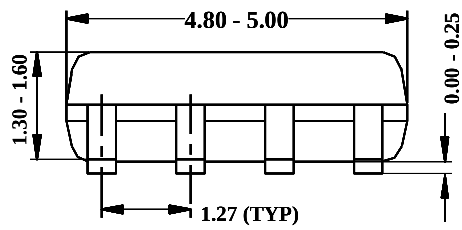
SO8E Package outline & PCB layout design





Recommended Pad Layout





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