Application Note: SY8746A

High Efficiency 60V, 0.8A, 350KHz Constant Current Step-down Regulator

General Description

SY8746A is a high efficiency, 12V-60V wide input voltage range DC/DC regulator targeting at LED lighting applications. The device integrates the low $R_{DS(ON)}$ MOSFET and internal compensation. Along with the small SO8E package, the device achieves an extremely small solution size for LED driver design. SY8746A also supports PWM dimming and Analog dimming function.

Features

- Low $R_{DS(ON)}$ for Internal Switches :680mΩ
- Input Range: 12V-60V
- 350kHz Switching Frequency
- 1.2A MOSFET Peak Current Limitation
- Analog/PWM Dimming Available
- Lower than 0.5% Deep Dimming Level
- Adjustable Thermal Foldback Temperature
- Dimming Resistor to Adjust Output Full Load
- Compact Package: SO8E

Ordering Information

SY8746 □(□□)□

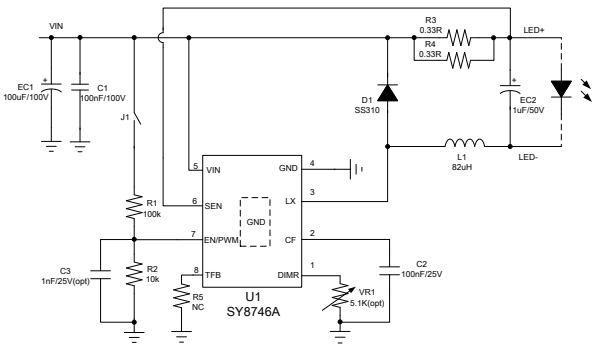
- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package type	Note
SY8746AFCC	SO8E	----

Applications

- PAR Lamp
- Tube Lamp
- Bulb

Typical Applications



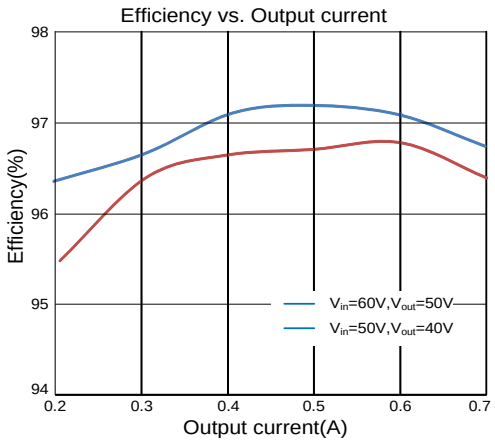
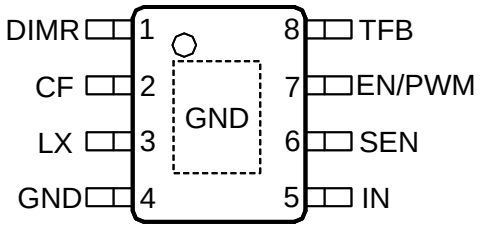


Figure 1. Schematic diagram

Pinout (top view)

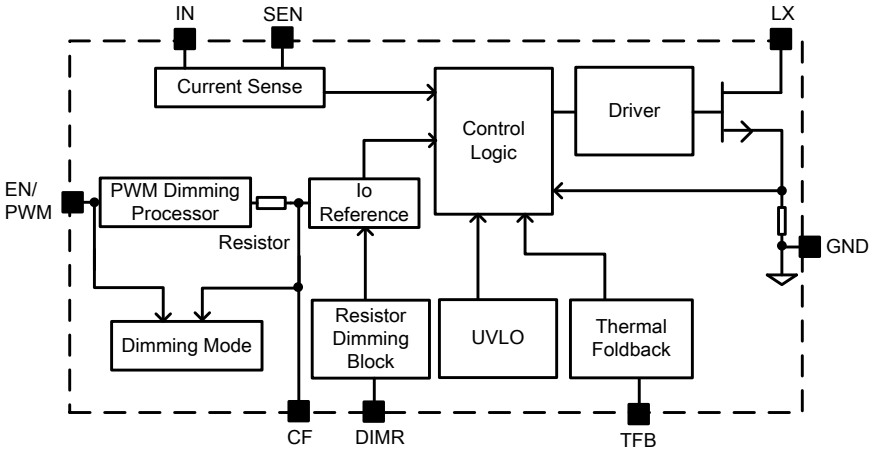


SO8E

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

PIN	Pin Name	Pin Description
1	DIMR	Resistor Dimming Pin, adjust output load from 100% to 75% by changing the external resistor. If no use, connect DIMR to GND.
2	CF	Dimming mode selection: VCF≥1.6V, PWM ON/OFF dimming mode. VCF≤1.4V, CF 0~1V analog dimming mode.
3	LX	Inductor node. Connect an inductor between negative of LED and LX Pin.
4	GND	Ground Pin
5	IN	Input Pin. Decouple this Pin to GND Pin with 1μF ceramic cap. Also used as the positive current sense Pin.
6	SEN	Negative Current Sense Pin.
7	EN/PWM	Dimming mode selection: 1. ON/OFF dimming mode： Connect EN/PWM Pin and CF Pin together, add PWM signal to PWM Pin, 2. 0~1.0V analog dimming mode： V_{PWM}≥8.5V, add 0~1.0V signal to CF Pin, at analog dimming mode, recommend to connect a 100nF capacitor between CF Pin and GND.
8	TFB	Thermal foldback temperature adjust Pin

Block Diagram



Absolute Maximum Ratings

LX, IN, PWM, CF---------- -0.3V to~ 63V
DIMR, TFB---------- -0.3V to~ 3.6V
SEN ----------0.3V to V_{IN}+0.6V
Power Dissipation, PD @ TA = 25°C SO8E, ---------- 3.3W
Package Thermal Resistance (Note 2)
θ_{JA} ---------- 30°C/W
θ_{JC} ---------- 10°C/W
Junction Temperature Range ---------- -40°C to 150°C
Lead Temperature (Soldering, 10 sec.) ---------- 260°C
Storage Temperature Range ---------- -65°C to 150°C

Recommended Operating Conditions

IN ---------- 12V to 60V
SEN ---------- V_{IN} +0.4V
Junction Temperature Range ---------- -40°C to 125°C

Electrical Characteristics

(VIN =48V, Vout=36V, Iout=100mA, TA = 25°C unless otherwise specified)

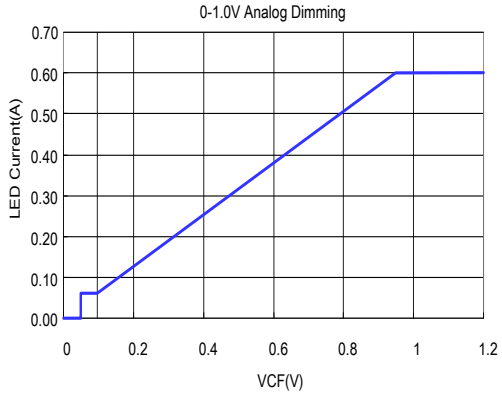
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supply Section						
Input Voltage Range	V_{IN}		12		60	V
Input UVLO Threshold	V_{UVLO_RISE}		9.8	10.4	10.9	V
Input UVLO Hysteresis	V_{UVLO_HYS}			2		V
Shutdown Current	I_{SHDN}	EN/PWM=0	5.5	8	11	μA
Operating Current	I_{VIN}	EN/PWM=3.3V	0.6	0.8	1	mA
Error Amplifier Section						
Internal Current Sense Reference	V_{IN_SEN}		98	100	102	mV
Min Current Sense Reference	$V_{IN\_SEN\_MIN}$		8.4	10	11.6	mV
Short Circuit Section						
Short Circuit Protection Voltage	V_{IN_SEN}		140	200	250	mV
Short circuit Recover Voltage	$V_{IN\_SEN\_RC}$		20	37	56	mV
Frequency Section						
Switching Frequency	F_s		280	350	410	kHz
Integrated MOSFET Section						
MOSFET ON Resistor	$R_{DS(ON)}$		600	680	800	mΩ
PWM Pin Section						
PWM ON Voltage	V_{PWM_ON}		1.7			V
PWM OFF Voltage	V_{PWM_OFF}				0.5	V
CF Pin Section						
CF ON Voltage	V_{CF_ON}			75		mV
CF OFF Voltage	V_{CF_OFF}			50		mV
Linear Dimming Range On CF	V_{CF}		100		950	mV
Other Section						
Thermal Foldback Temperature	T_{FB}	R_{FB}=0		105		℃
		R_{FB}≥100k		155		
Thermal Shutdown Temperature	T_{SD}			T_{FB} +10		℃

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.

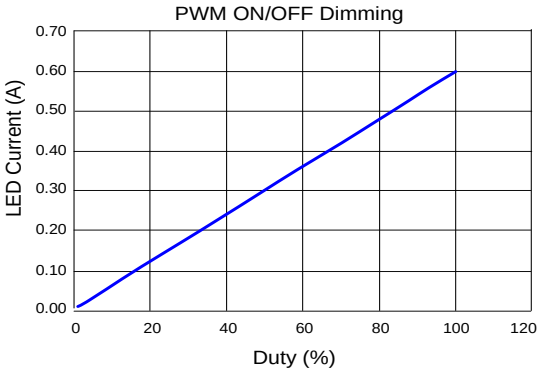
Note 2: θ_{JA} is measured in the natural convection at TA = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

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

Typical Performance Characteristics



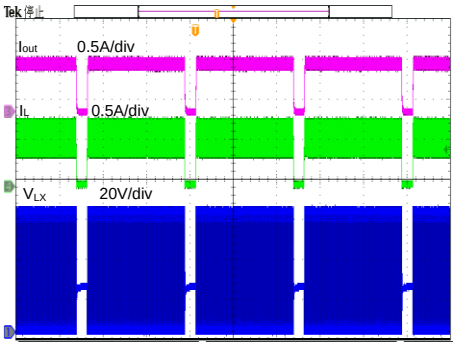
CF 0~1V dimming mode (R_{DIMR}=0)



PWM ON/OFF dimming mode (R_{DIMR}=0)

PWM ON/OFF Dimming

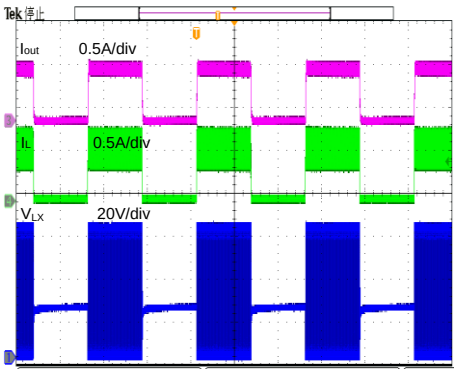
(V_{IN}=60V, V_O=40V,I_O=0.6A,90% Duty)



Time (400μs/div)

PWM ON/OFF Dimming

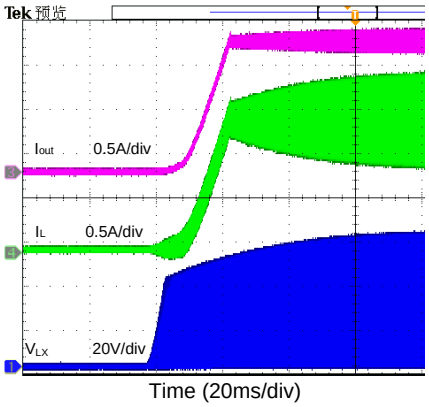
(V_{IN}=60V, V_O=40V,I_O=0.6A,50% Duty)



Time (400μs/div)

Startup

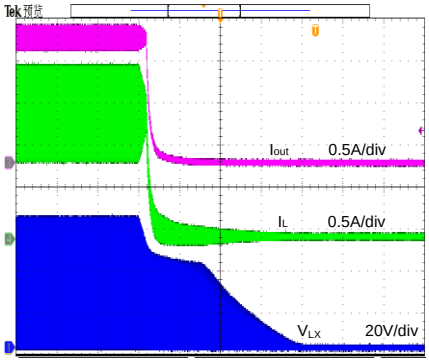
(V_{IN}=60V,V_O=40V,I_O=0.6A)



Time (20ms/div)

Shutdown

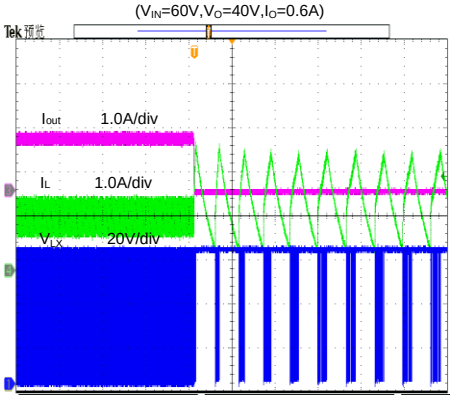
(V_{IN}=60V,V_O=40V,I_O=0.6A)



Time (40ms/div)

Short LED

(V_{IN}=60V,V_O=40V,I_O=0.6A)



Time (200μs/div)

Operation

SY8746A is a grounding switch buck regulator IC that integrates the PWM control, power MOSFET on the same die to minimize the switching transition loss and conduction loss. With ultra low $R_{DS(ON)}$ power MOSFET and proprietary PWM control, this regulator IC can achieve the high efficiency and Along with the small SO8E package, the device achieves an extremely small solution size for LED driver design. SY8746A also supports PWM/Analog dimming function.

Applications Information

Because of the high integration in the SY8746A IC, the application circuit based on this regulator IC is rather simple. Only input capacitor C_{IN}, output capacitor C_{OUT}, output inductor L and current sense resistor R_{SEN} need to be selected for the targeted applications specifications.

Current Sense Resistor R_{SEN}:

Choose R_{SEN} to program the proper output Current:

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

Input Capacitor C_{IN}:

The ripple current through input capacitor is calculated as:

$$I_{CIN\_RMS} = I_{OUT} \cdot \sqrt{D(1-D)}$$

A typical X7R or better grade ceramic capacitor with suitable capacitance should be chosen to handle this ripple current well. To minimize the potential noise problem, place this ceramic capacitor really close to the IN and GND pins. Care should be taken to minimize the loop area formed by C_{IN}, and IN/GND pins.

Output Capacitor C_{OUT}:

The output capacitor is selected to handle the output current ripple noise requirements. For the best performance, it is recommended to use X7R or better grade ceramic capacitor greater than 1μF capacitance.

Output Inductor L:

There are several considerations in choosing this inductor.

1) Choose the inductance to provide the desired ripple current. It is suggested to choose the ripple current to be about 40% of the maximum output current. The inductance is calculated as:

$$L = \frac{V_{OUT}(1 - V_{OUT}/V_{IN,MAX})}{f_S \times I_{OUT,MAX} \times 40\%}$$

where fs is the switching frequency and $I_{OUT,MAX}$ is the LED current.

The SY8746A regulator IC is quite tolerant of different ripple current amplitude. Consequently, the final choice of inductance can be slightly off the calculation value without significantly impacting the performance.

2) The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions.

$$I_{SAT,MIN} > I_{OUT,MAX} + \frac{V_{OUT}(1-V_{OUT}/V_{IN,MAX})}{2 \cdot F_{SW} \cdot L}$$

Dimming Operation:

Dimming Mode:

1: PWM ON/OFF dimming. Connect EN/PWM Pin and CF Pin together, add PWM signal to PWM Pin.

2: 0~1.0V analog dimming. Set $V_{EN} \geqslant 8.5V$, and add 0~1.0V dimming signal to CF PIN.

Dimming mode	PWM	CF
PWM ON/OFF dimming	Connect PWM and CF together	
0~1.0V analog dimming	PWM⩾8.5V	⩽1.4V

At PWM dimming mode, the minimum T_{PWM_ON} time is suggest setting bigger than 20μs.

Soft Start:

Add a ceramic capacitor C_{CF} on CF to achieve soft start, the soft start time can be adjusted by C_{CF}.

SCP:

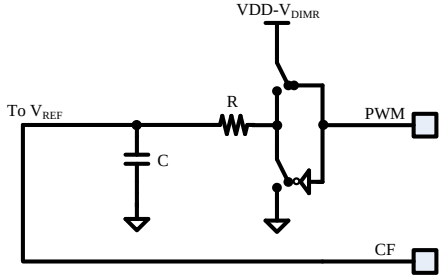
If V_{VIN}-V_{SEN}>=200mV, PWM is disabled, When V_{VIN}-V_{SEN} =35mV, IC will recover work.

EN OFF:

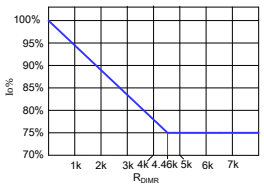
IC shut down after EN OFF with 18.5ms.

Rdimr Dimming:

Add R_{DIMR} between DIMR and GND, 56uA current is output from DIMR PIN. The max output current vary from 100% to 75% by changing R_{DIMR}, and VDD (1v) is became VDD-I_{DIMR}*R_{DIMR}. No matter how R_{DIMR} changes, The max of I_{DIMR}*R_{DIMR} is keeping 250mV, as well V_{REF} is keeping 5mV when VCF≤0.1V.



The max output current Io% curve with R_{DIMR} as below:



Layout Design:

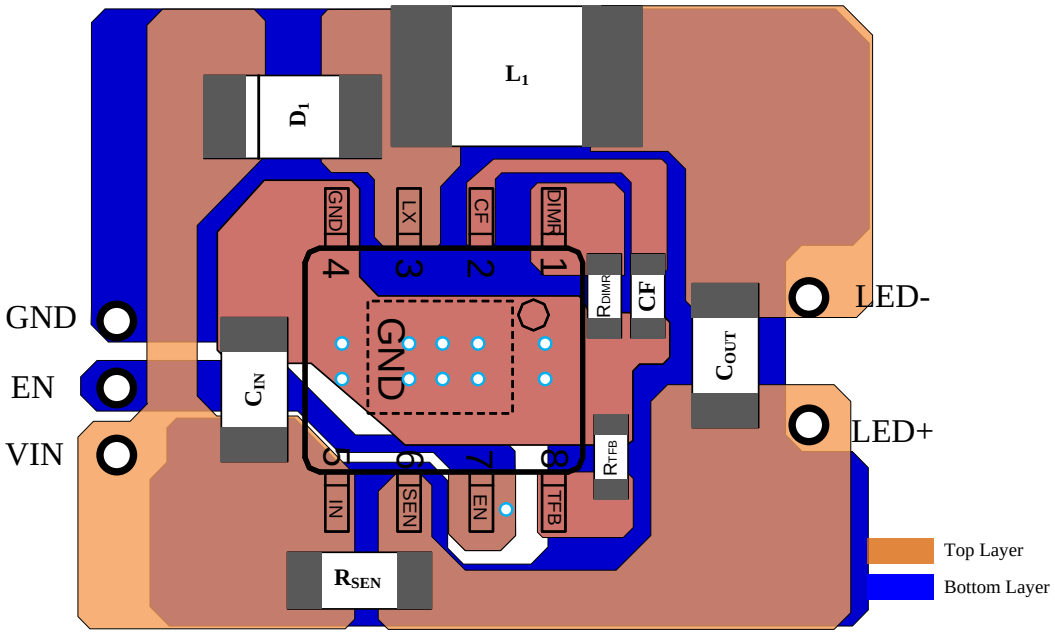
The layout design of SY8746A regulator is relatively simple. For the best efficiency and minimum noise problems, we should place the following components close to the IC: C_{IN}, L, C_{OUT}, CF and R_{SEN}.

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.

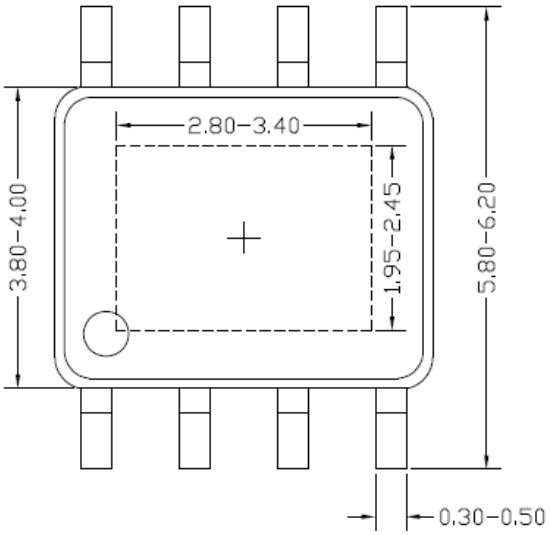
2) C_{IN} must be close to Pins IN and GND. The loop area formed by C_{IN} and GND must be minimized.

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

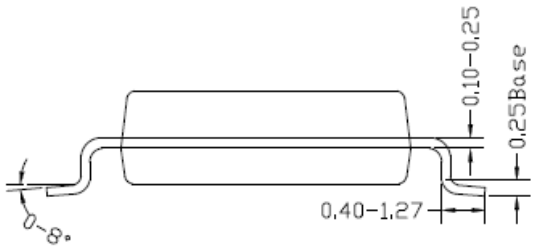
PCB Layout Suggestion



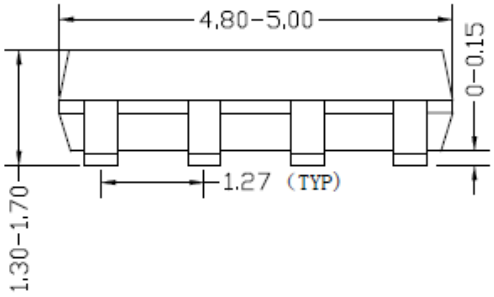
SO8E Package Outline & PCB layout



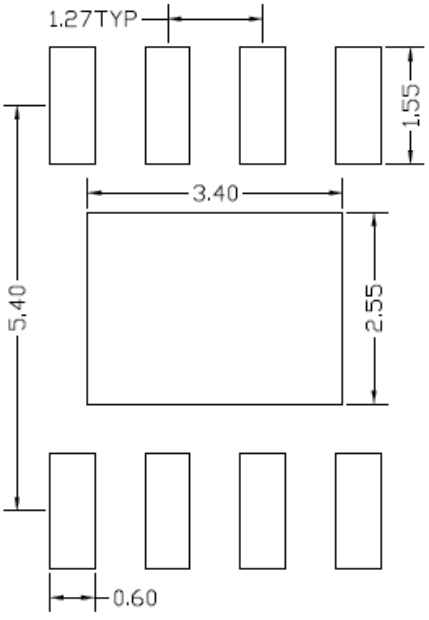
Top view



Side view



Front view

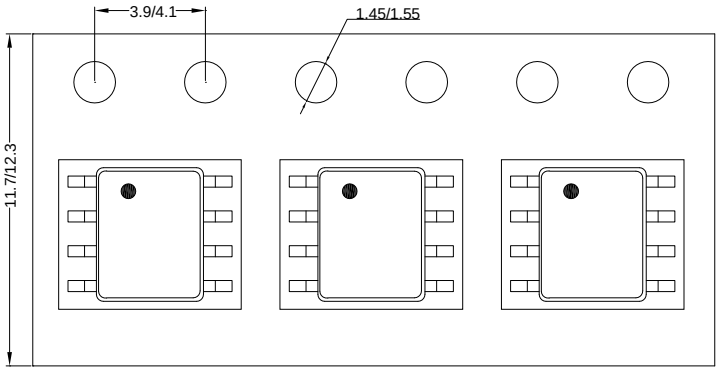


Recommended PCB Layout (Reference Only)

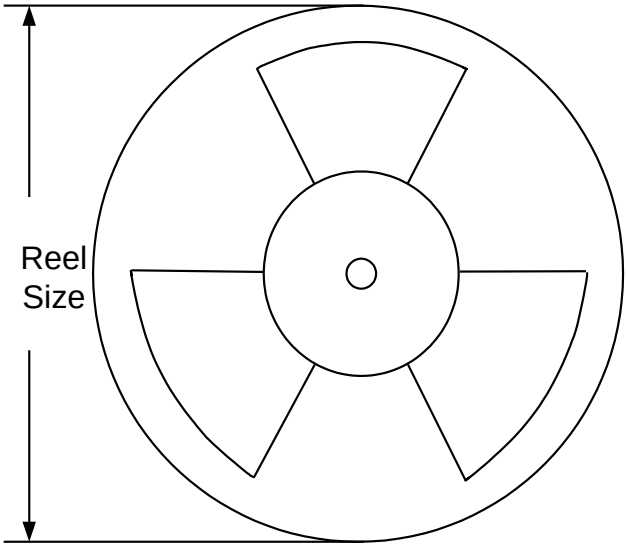
Notes: All dimension in millimeter and exclude mold flash & metal burr.

Taping & Reel Specification

1. SO8E



2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
SO8E	12	8	13"	400	400	2500

3. Others: NA

Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
June 17, 2019	Revision 0.9	Initial Release

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