Application Note: SY8893L

High Efficiency, 1.2MHz, 3A Synchronous Step Down Regulator

General Description

The SY8893L is a high efficiency 1.2MHz synchronous step down DC/DC regulator, which is capable of delivering up to 3A output currents. It can operate over a wide input voltage range from 2.5V to 5.5V and integrate main switch and synchronous switch with very low $R_{DS(ON)}$ to minimize the conduction loss.

The SY8893L integrates the reliable latch-off function when output over voltage, output under voltage or thermal shutdown happens.

The SY8893L is in a space saving, low profile SOT563 package.

Features

- 2.5V to 5.5V Input Voltage Range
- 50μA Low Quiescent Current
- Low $R_{DS(ON)}$ for Internal Switches (Top/Bottom) 100mΩ /60mΩ
- High Switching Frequency 1.2MHz Minimizes the External Components
- Internal Soft-start Limits the Inrush Current
- 100% Dropout Operation
- Power Good Indicator
- Reliable Latch off Function When:
  - ➢ Output Under Voltage
  - ➢ Thermal Shutdown
  - ➢ Output Voltage>120% of Regulated Voltage
- Output Auto Discharge Function
- RoHS Compliant and Halogen Free
- Compact Package: SOT563

Ordering Information

SY8893 □(□□)□

- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package type	Note
SY8893LARC	SOT563	--

Applications

- Set Top Box
- USB Dongle
- Media Player
- Smart phone

Typical Applications

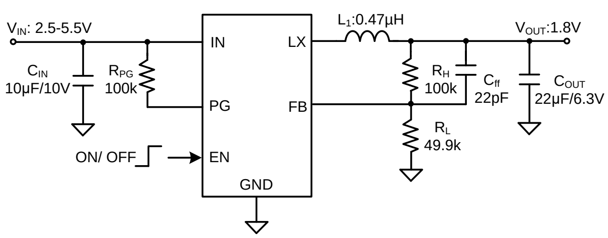


Figure1. Schematic Diagram

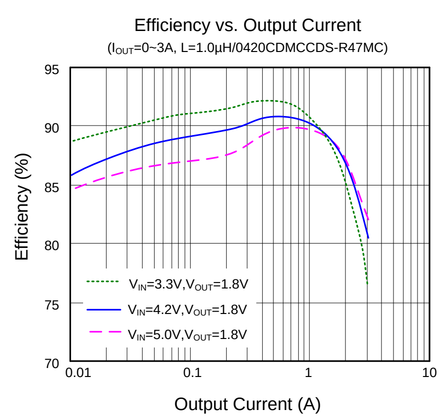
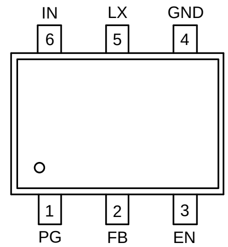


Figure2. Efficiency vs. Output Current

Inductor and C_{OUT} Selection Table

V_{OUT}[V]	L[μH]	C_{OUT}[μF]			
		10	22	2×22	3×22
1.2/1.8/3.3	0.47		☆	√	√
	1.0		√	√	√
	2.2		√	√	√

Pinout (Top View)



(SOT563)

Top Mark: C3*xyz* (device code: C3, ***x=year code, y=week code, z= lot number code)***

Pin Name	Pin Number	Pin Description
PG	1	Power good indicator (open drain output). Low if the output < 90% or the output >120% of regulation voltage; High otherwise. Connect a pull-up resistor to the input.
FB	2	Output Feedback Pin. Connect this pin to the center point of the output resistor divider (as shown in Figure 1) to program the output voltage: V_{OUT}=0.6×(1+R_H/R_L).
EN	3	Enable control. Pull high to turn on. Do not leave it floating.
GND	4	Ground pin.
LX	5	Inductor pin. Connect this pin to the switching node of inductor.
IN	6	Input pin. Decouple this pin to GND pin with at least a 10μF ceramic capacitor.

Block Diagram

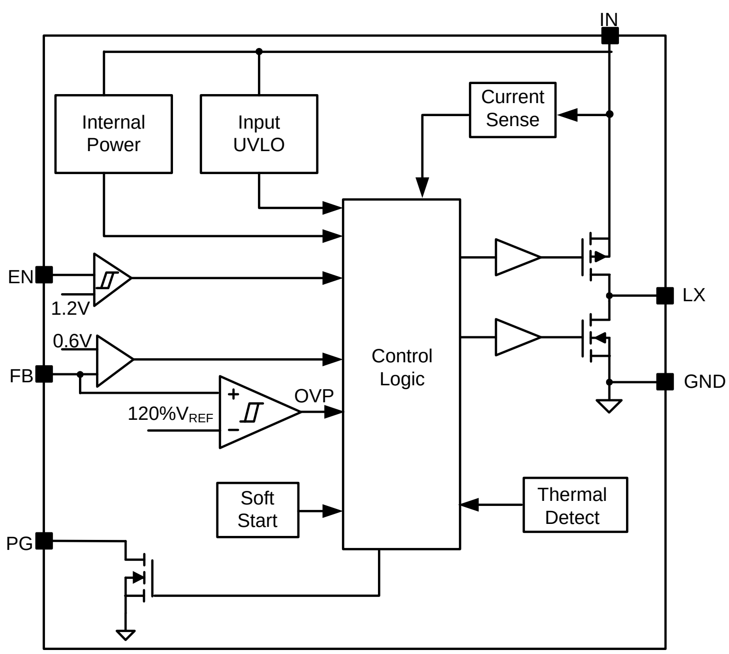


Figure3. Block Diagram

Absolute Maximum Ratings (Note 1)

Supply Input Voltage -- -0.3V to 6.0V
PG, FB, EN Voltage-- -0.3V to V_{IN}+0.6V
LX Voltage -- -0.3V(*1) to 6.0V(*2)
Power Dissipation, P_D @ T_A = 25℃ -- 1.4W
Package Thermal Resistance (Note 2)
θ_{JA} -- 70℃/W
θ_{JC} -- 8℃/W
Junction Temperature Range -- -40℃ to 150℃
Lead Temperature (Soldering, 10 sec.) -- 260℃
Storage Temperature Range -- -65℃ to 150℃
(*1) LX Voltage Tested Down to -3V<40ns
(*2) LX Voltage Tested Up to +7V<40ns

Recommended Operating Conditions (Note 3)

Supply Input Voltage -- 2.5V to 5.5V
Junction Temperature Range -- -40℃ to 125℃
Ambient Temperature Range -- -40℃ to 85℃

Electrical Characteristics

(V_{IN} = 5V, V_{OUT} = 1.8V, L = 0.47μH, C_{OUT} = 22μF, T_A = 25 ℃, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		2.5		5.5	V
Input UVLO Threshold	V_{UVLO}				2.5	V
Input UVLO Hysteresis	V_{HYS}			0.15		V
Quiescent Current	I_Q	V_{FB}=V_{REF}×105%		50	70	μA
Shutdown Current	I_{SHDN}	V_{EN}=0V		0.1	1	μA
Feedback Reference Voltage	V_{REF}	I_{OUT}=1A，CCM	591	600	609	mV
Output Discharge Resistance	R_{DIS}			50		Ω
Top FET R_{ON}	$R_{DS(ON)1}$			100		mΩ
Bottom FET R_{ON}	$R_{DS(ON)2}$			60		mΩ
EN Input Voltage High	$V_{EN,H}$		1.2			V
EN Input Voltage Low	$V_{EN,L}$				0.4	V
PG Threshold for Under Voltage Detection	$V_{PG,UVP}$			90		%V_{REF}
PG Low Delay Time for Under Voltage Detection	$t_{UVP,DLY}$			20		μs
PG Threshold for Over Voltage Detection	$V_{PG,OVP}$			120		%V_{REF}
PG Low Delay Time for Over Voltage Detection	$t_{OVP,DLY}$			20		μs
Min ON Time	$t_{ON,MIN}$			60		ns
Maximum Duty Cycle	D_{MAX}		100			%
Turn On Delay	$t_{ON,DLY}$	from EN high to LX start switching		300		μs
Soft-start Time	t_{SS}			700		μs
Switching Frequency	f_{SW}	I_{OUT}=1A，CCM		1.2		MHz
Top FET Current Limit	$I_{LMT,TOP}$		4			A
Output Under Voltage Protection Threshold	V_{UVP}			50		%V_{REF}
Output UVP Delay	$t_{UVP,DLY}$			5		μs
Thermal Shutdown Temperature	T_{SD}			160		˚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 ℃ on 2OZ four-layer Silergy evaluation board. Pin 5 of case position for SY8893LARC θ_{JC} measurement.

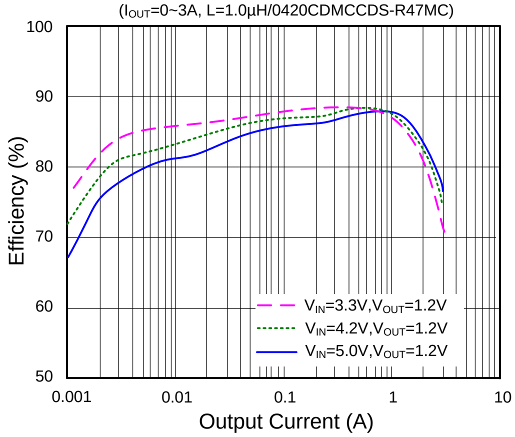
Note 3: The device is not guaranteed to function outside its operating conditions.

Typical Performance Characteristics

(T_A = 25 ℃, V_{IN} = 5V, V_{OUT} = 1.8V, L = 0.47μH, C_{OUT} = 22μF, unless otherwise noted.)

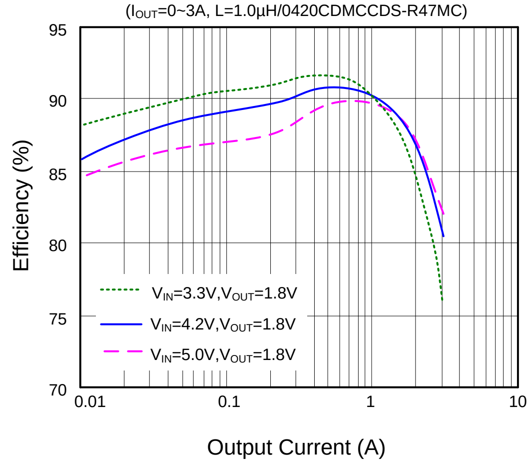
Efficiency vs. Output Current

(I_{OUT}=0~3A, L=1.0μH/0420CDMCCDS-R47MC)



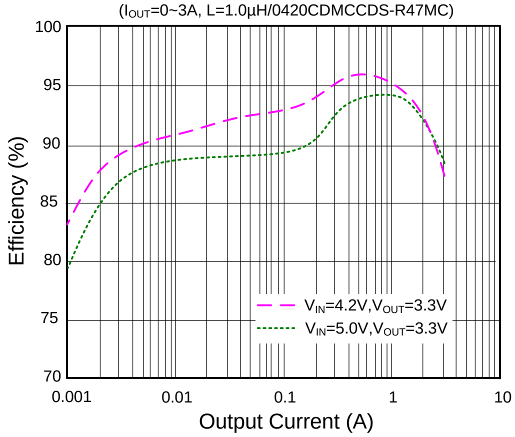
Efficiency vs. Output Current

(I_{OUT}=0~3A, L=1.0μH/0420CDMCCDS-R47MC)



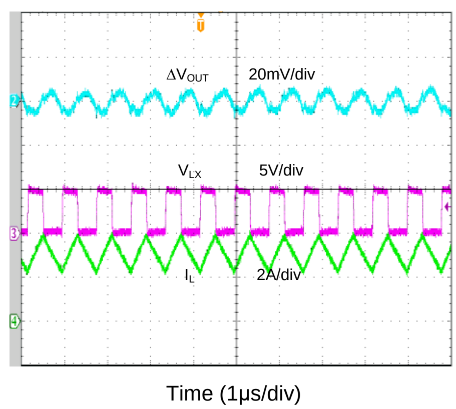
Efficiency vs. Output Current

(I_{OUT}=0~3A, L=1.0μH/0420CDMCCDS-R47MC)



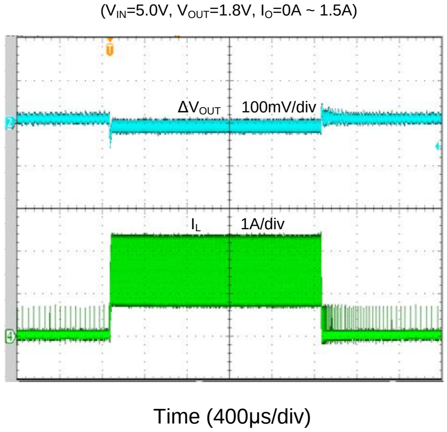
Output Ripple

(V_{IN}=5.0V, V_{OUT}=1.8V, I_O=3.0A)



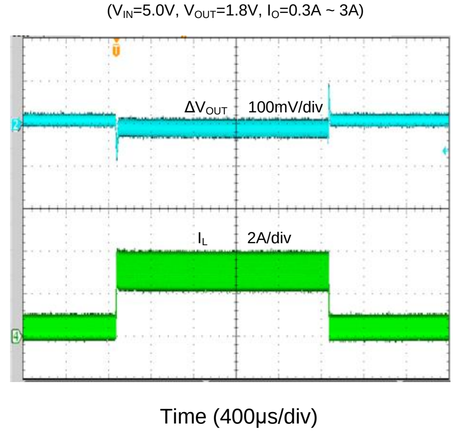
Load Transient

(V_{IN}=5.0V, V_{OUT}=1.8V, I_O=0A ~ 1.5A)



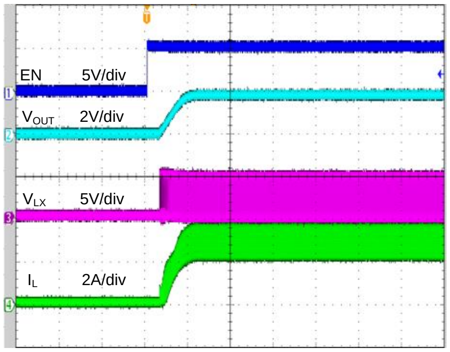
Load Transient

(V_{IN}=5.0V, V_{OUT}=1.8V, I_O=0.3A ~ 3A)



Startup from Enable

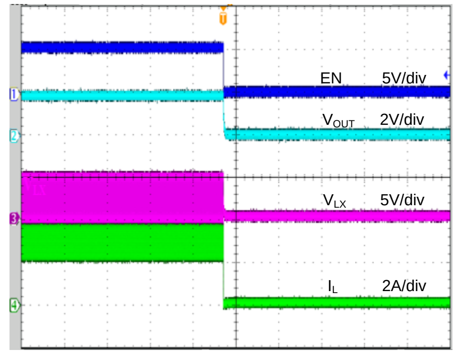
(V_{IN}=5.0V, V_{OUT}=1.8V, R_{LOAD}=0.6Ω)



Time (800µs/div)

Shutdown from Enable

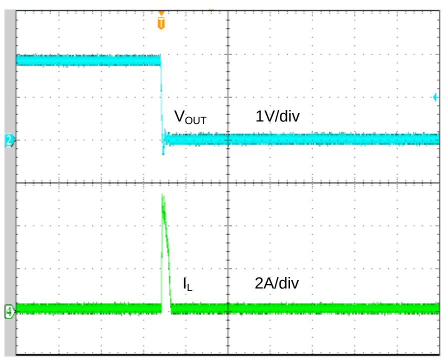
(V_{IN}=5.0V, V_{OUT}=1.8V, R_{LOAD}=0.6Ω)



Time (800µs/div)

Short Circuit Protection

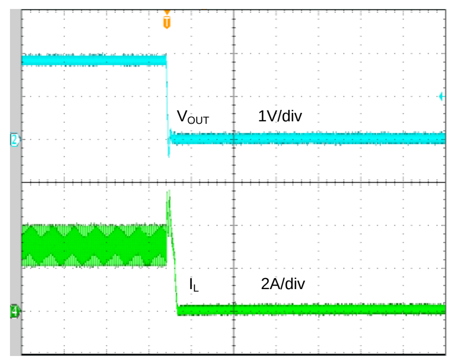
(V_{IN}=5.0V, V_{OUT}=1.8V,I_O=0A~Short)



Time (40µs/div)

Short Circuit Protection

(V_{IN}=5.0V,V_{OUT}=1.8V,I_O=3A~Short)



Time (40µs/div)

Operation

The SY8893L is a high efficiency 1.2MHz synchronous step down DC/DC regulator, which is capable of delivering up to 3A output currents. It can operate over a wide input voltage range from 2.5V to 5.5V and integrate main switch and synchronous switch with very low $R_{DS\ (ON)}$ to minimize the conduction loss.

The SY8893L integrates the reliable latch-off function when output over voltage, output under voltage or thermal shutdown happens.

The SY8893L is in a space saving, low profile SOT563 package.

Short Circuit Protection

After the soft-start is over, if the output voltage falls below 50% of the regulation level, the IC will turn off both power switches, then will enter short circuit protection. It will remain in this state until the IN or EN voltage is recycled.

Over Voltage Protection

If the output voltage exceeds 120% of the regulation level, the IC will turn off both power switches and turn on the discharge switch, then will enter over voltage protection. It will remain in this state until the IN or EN voltage is recycled.

Thermal Shutdown Protection

If the junction temperature of the SY8893L is greater than the thermal shutdown temperature (T_{SD}), the IC will turn off both power switches, and then will enter thermal shutdown protection. It will remain in this state until the IN or EN voltage is recycled.

Applications Information

Because of the high integration in the SY8893L, the application circuit based on this regulator is rather simple. Only the input capacitor C_{IN}, the output capacitor C_{OUT}, the output inductor L and the feedback resistors (R_H and R_L) need to be selected for the targeted application specifications.

Feedback Resistor Dividers R_H and R_L

Choose R_H and R_L to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both R_H and R_L. A value of between 1kΩ and 1MΩ is highly recommended for both resistors. If R_L =120kΩ is chosen, then R_H can be calculated to be:

$$R_H = \frac{(V_{OUT} - 0.6\,V) \times R_L}{0.6V}$$

Input Capacitor C_{IN}

A typical X5R or better grade ceramic capacitor with 10V rating and greater than 10μF capacitance is recommended. To minimize the potential noise problem, this ceramic capacitor should be placed 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 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:

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

Where f_{SW} is the switching frequency and $I_{OUT,MAX}$ is the maximum load current.

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

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

3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. It is desirable to choose an inductor with DCR<25mΩ to achieve a good overall efficiency.

Load Transient Considerations

The SY8893L integrates the compensation components to achieve good stability and fast transient responses. In some applications, adding a 22pF ceramic capacitor in parallel with R_H may further speed up the load transient responses and is thus recommended for applications with large load transient step requirements.

OCP Protection Method

With load current increasing, as soon as the high side FET current gets higher than peak current limit threshold, the high side FET will turn off. If the load current continues to increase, the output voltage will drop. When the output voltage falls below 50% of the regulation level, the output UVP will be detected and the SY8893L will operate in latch off mode.

Layout Design

The layout design of the SY8893L is relatively simple. For the best efficiency and to minimize noise problems, the following components should be placed close to the IC: C_{IN}, L, R_H and R_L.

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. Reasonable paths are suggested to be placed underneath the ground pad to enhance the soldering quality and thermal performance.
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 the LX pin must be minimized to avoid the potential noise problem.
4) The components R_H and R_L, and the trace connecting to the FB pin must NOT be adjacent to the LX net on the PCB layout to avoid the noise problem.

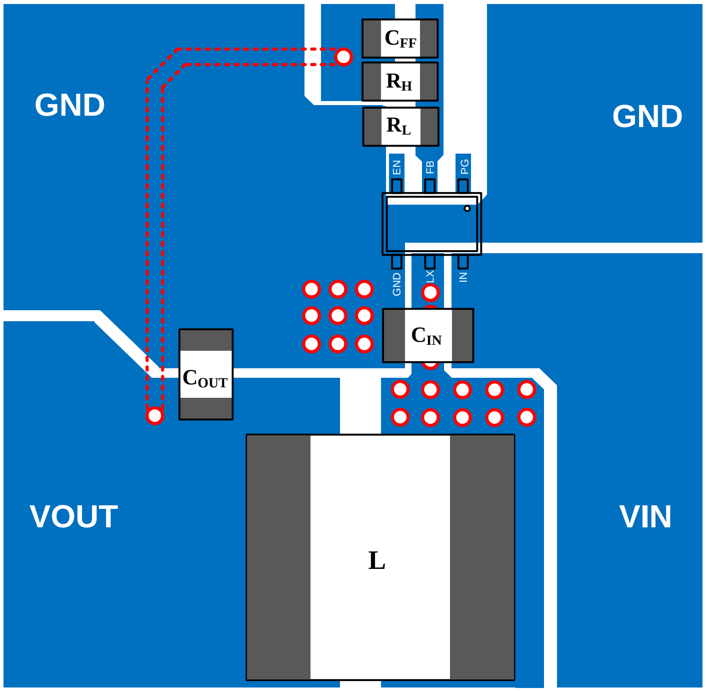
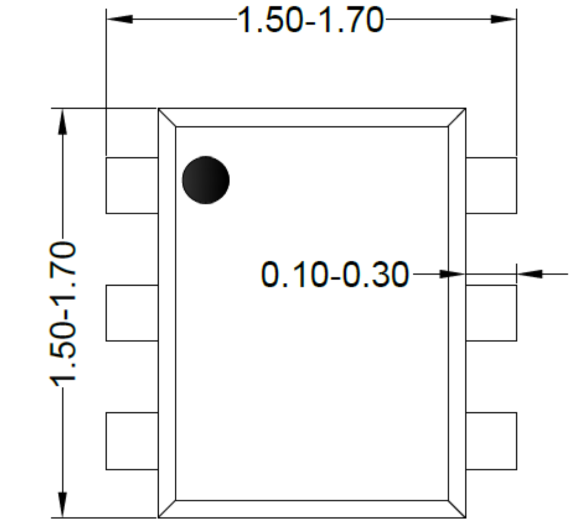
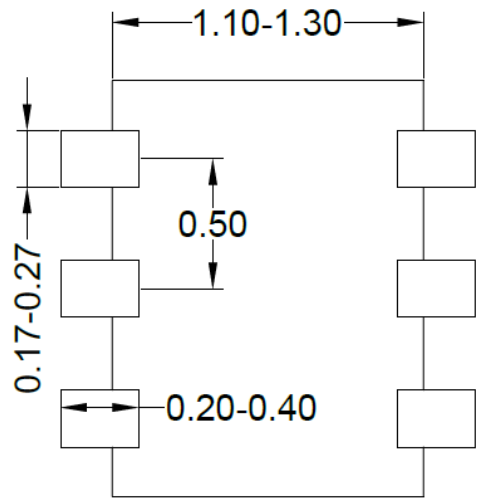


Figure4. PCB Layout Suggestion

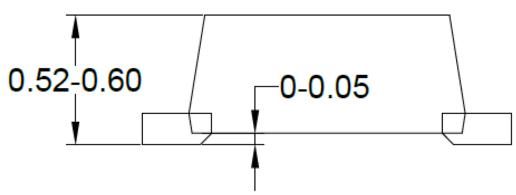
SOT563 Package Outline Drawing



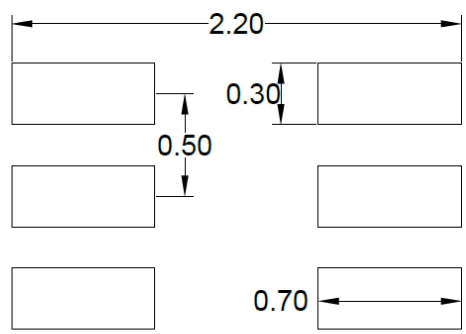
Top view



Bottom view



Side View



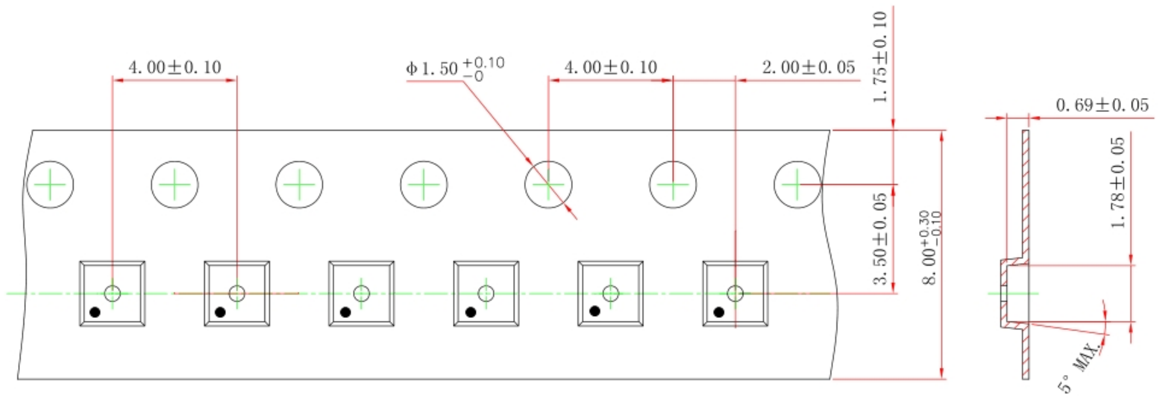
Recommended PCB layout (Reference only)

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

Taping & Reel Specification

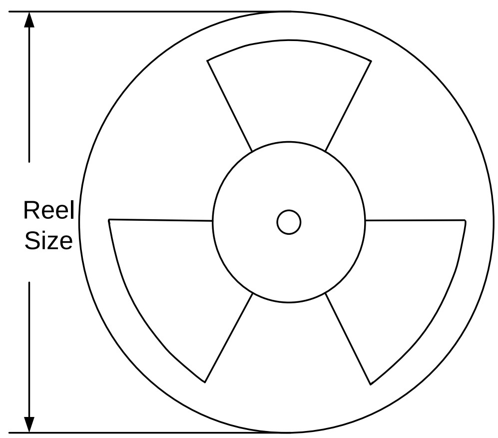
1. Taping Orientation

SOT563



Feeding Direction →

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 (pcs)
SOT563	8	4	7"	280	160	5000

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**
Aug.25, 2020	Revision 0.9	Initial Release

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