SY20121

High Efficiency 2.0MHz, 1.5A Synchronous Step Down Regulator

General Description

SY20121 is a high efficiency 2.0MHz synchronous step down DC/DC regulator capable of delivering up to 1.5A output currents. It can operate over a wide input voltage range from 2.6V to 5.5V and integrate main switch and synchronous switch with very low $R_{DS\,(ON)}$ to minimize the conduction loss.

Low output voltage ripple, small external inductor and capacitor sizes are achieved with 2.0MHz switching frequency.

Features

- 2.6~5.5V Input Voltage Range
- 55μA Low Quiescent Current
- Ultra Fast Load Transient Speed
- Low $R_{DS(ON)}$ for Internal Switches (Top/Bottom) 180mΩ /100mΩ
- High Switching Frequency 2.0MHz Minimizes the External Components
- Internal Soft-start Limits the Inrush Current
- Output Auto Discharge Function
- RoHS Compliant and Halogen Free
- Compact Package: SOT563

Ordering Information

SY20121□(□,□)□

- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package Type	Note
SY20121ARC	SOT563	----

Applications

- Smart Phone
- Net PC
- Mini-notebook PC
- Access Point Router

Typical Application

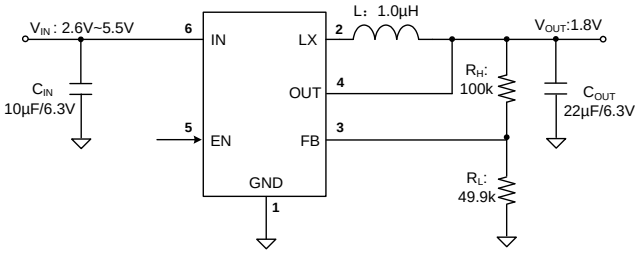


Figure1. Schematic Diagram

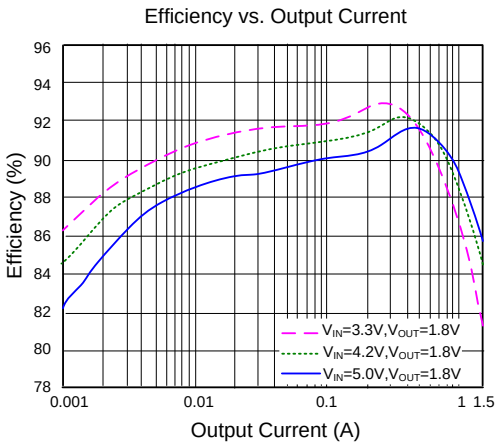
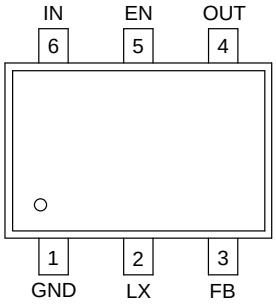


Figure2. Efficiency vs. Output Current

Pin out (Top View)



(SOT563)

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

Pin Name	Pin Number	Pin Description
GND	1	Ground pin.
LX	2	Inductor pin. Connect this pin to the switching node of inductor.
FB	3	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}=0.6V× (1+R_H/R_L)
OUT	4	Output feedback pin, connect to the output capacitor side.
EN	5	Enable control. Pull high to turn on. Do not leave it floating.
IN	6	Input pin. Decouple this pin to GND pin with at least a 10μF ceramic cap.

Block Diagram

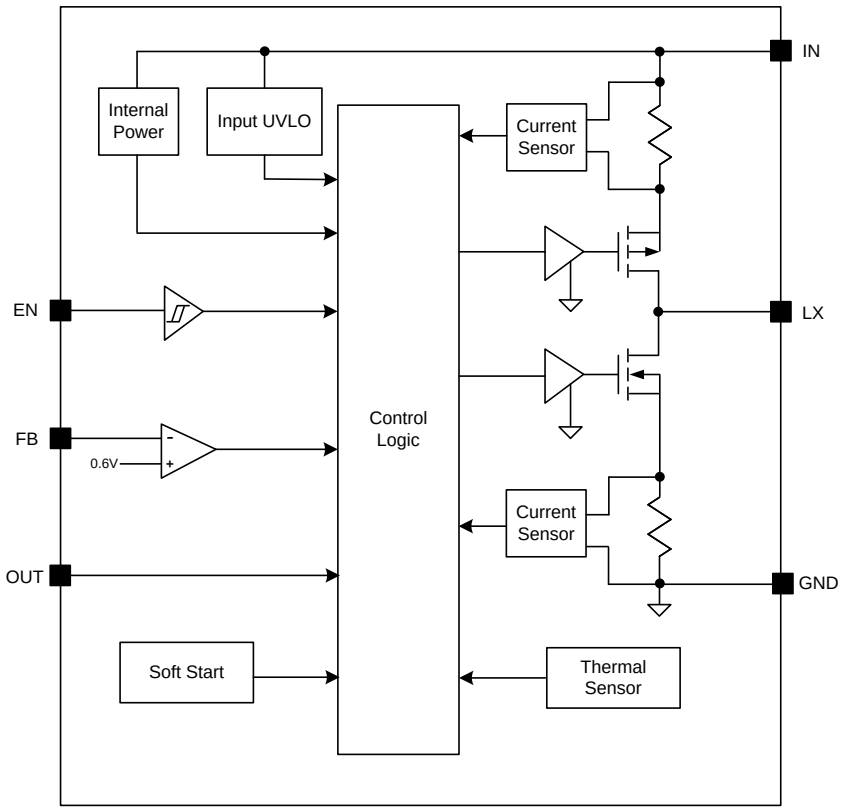


Figure3. Block Diagram

Absolute Maximum Ratings (Note 1)

Supply Input Voltage ---------- 6.0V
EN, PG, OUT, FB Voltage---------- V_{IN} + 0.6V
LX Voltage ---------- -0.3V (*1) to 6V (*2)
Power Dissipation, P_D @ T_A = 25°C,
SOT563 ---------- 1.07W
Package Thermal Resistance (Note 2)
θ_{JA} ---------- 93°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
(*1) LX Voltage Tested Down to -3V<40ns
(*2) LX Voltage Tested Up to +7V<40ns

Recommended Operating Conditions (Note 3)

Supply Input Voltage ---------- 2.6V to 5.5V
Junction Temperature Range ---------- -40°C to 125°C
Ambient Temperature Range ---------- -40°C to 85°C

Electrical Characteristics

(V_{IN} =5.0V, V_{OUT} = 1.8V, L = 1.0μH, C_{OUT} = 22μF, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		2.6		5.5	V
Input UVLO Threshold	V_{UVLO}				2.6	V
Input UVLO Hysteresis	V_{HYS}			0.15		V
Quiescent Current	I_Q	$V_{FB}=V_{REF}\times105\%$		55		μA
Shutdown Current	I_{SHDN}	V_{EN}=0V		0.1	1	μA
Feedback Reference Voltage	V_{REF}	I_{OUT}=0.5A	594	600	606	mV
LX Node Discharge Resistance	R_{DIS}			50		Ω
Top FET R_{ON}	$R_{DS(ON)1}$			180		mΩ
Bottom FET R_{ON}	$R_{DS(ON)2}$			100		mΩ
EN Input Voltage High	$V_{EN,H}$		1.1			V
EN Input Voltage Low	$V_{EN,L}$				0.4	V
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		100		μs
Soft-start Time	t_{SS}			0.4		ms
Switching Frequency	F_{SW}	I_{OUT}=0.5A		2.0		MHz
Top FET Current Limit	$I_{LMT,TOP}$		1.8			A
Bottom FET Current Limit	$I_{LMT,BOT}$		1.5			A
Output Under Voltage Protection Threshold	V_{UVP}			40		$\%V_{REF}$
Output UVP Delay	$t_{UVP,DLY}$			15		μs
Thermal Shutdown Temperature	T_{SD}			150		˚C
Thermal Shutdown Hysteresis	T_{HYS}			15		˚C

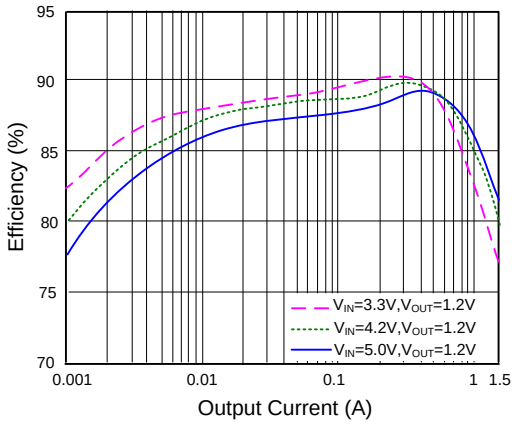
Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: θ_{JA} of SY20121ARC is measured in the natural convection at T_A = 25°C on 2OZ two-layer Silergy evaluation board. Pin 2 is the case position for SY20121ARC θ_{JC} measurement.

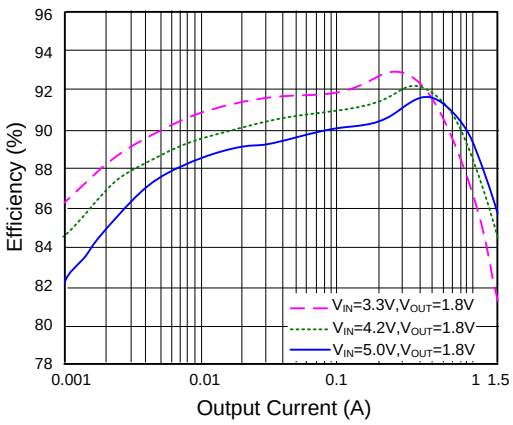
Note 3: The device is not guaranteed to function outside its operating conditions.

Typical Performance Characteristics

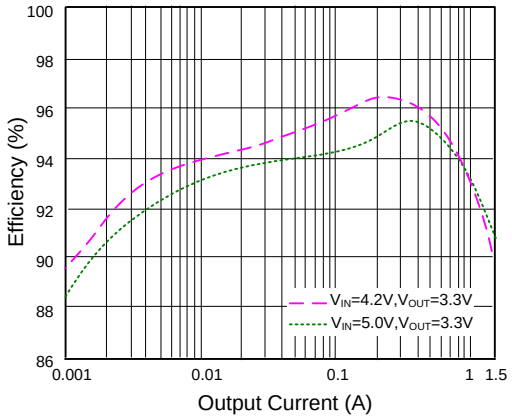
Efficiency vs. Output Current



Efficiency vs. Output Current

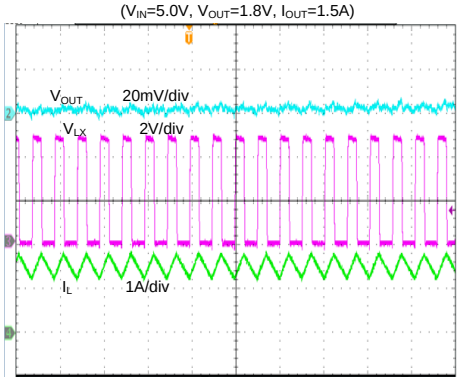


Efficiency vs. Output Current



Output Ripple

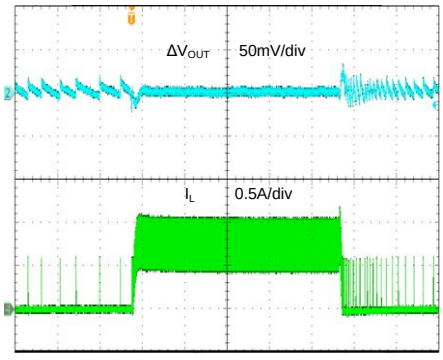
(VIN=5.0V, VOUT=1.8V, IOUT=1.5A)



Time (1μs/div)

Load Transient

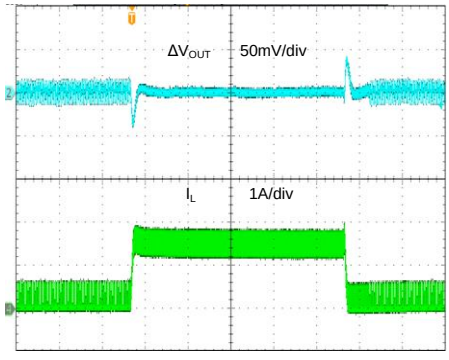
(VIN=5.0V, VOUT=1.8V, IO=0 ~ 0.75A)



Time (100μs/div)

Load Transient

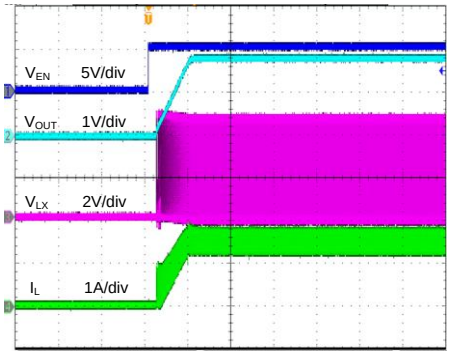
(VIN=5.0V, VOUT=1.8V, IO=0.15A~ 1.5A)



Time (100μs/div)

Startup from Enable

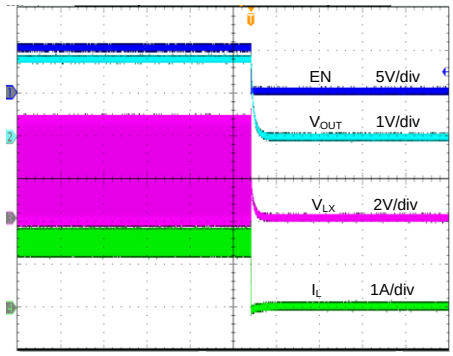
(V_{IN}=5.0V, V_{OUT}=1.8V, I_O=1.5A)



Time (400μs/div)

Shutdown from Enable

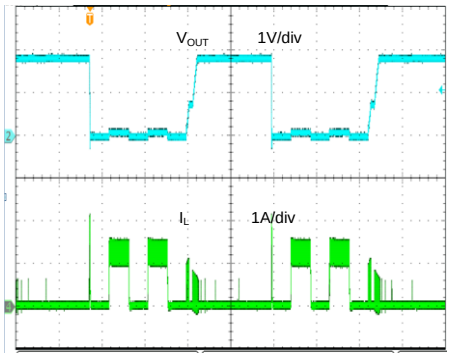
(V_{IN}=5.0V, V_{OUT}=1.8V, I_O=1.5A)



Time (400μs/div)

Short Circuit Protection

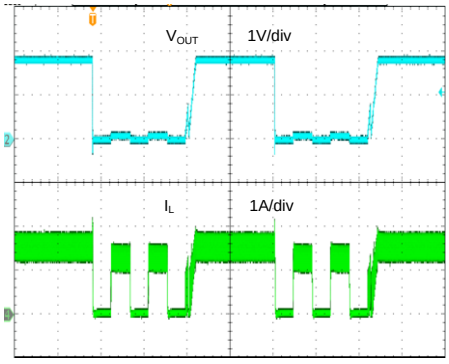
(V_{IN}=5.0V, V_{OUT}=1.8V, I_O=0A ~ short)



Time (2ms/div)

Short Circuit Protection

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



Time (2ms/div)

Operation

SY20121 is a high efficiency 2.0MHz synchronous step down DC/DC regulator capable of delivering up to 1.5A output currents. It can operate over a wide input voltage range from 2.6V to 5.5V and integrate main switch and synchronous switch with very low $R_{DS(ON)}$ to minimize the conduction loss.

Low output voltage ripple, small external inductor and capacitor sizes are achieved with 2.0MHz switching frequency.

Applications Information

Because of the high integration in the SY20121, the application circuit based on this regulator is rather simple. Only input capacitor C_{IN}, output capacitor C_{OUT}, output inductor L and 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 100kΩ and 1MΩ is highly recommended for both resistors. If R_L =100kΩ is chosen, then R_H can be calculated to be:

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

Input Capacitor C_{IN}:

A typical X5R or better grade ceramic capacitor with 6.3V rating and no less than 10uF capacitance is recommended. To minimize the potential noise problem, we 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 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.

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

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.

Inductor vs. Output Capacitor:

The ripple base control strategy need very little C_{OUT} to confirm stability. Too large inductor and C_{OUT} will lead to unstability. The recommend inductance and output capacitor is shown as below.

Inductance vs. Output Capacitor Selection Table

L	C_{OUT}					
	22μF	44μF	88μF	120μF	180μF	220μF
0.47μH	√	√	√	√	√	√
0.68μH	√	√	√	√	√	√
1.0μH	√	√	√	√	×	×

OCP and SCP 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 and the low side FET will keep turning on until low side FET current decrease below the valley current limit threshold. If peak current limit is trigged twice, the valley current limit threshold will fold-back to 80%.
If the load current continues to increase, the output voltage will drop. When the output voltage falls below 40% of the regulation level, the output UVP is detected and SY20121 will operate in hip-cup mode. The hip-cup frequency is 600Hz, the hip-cup duty cycle is 50%. If the hard short is removed, the IC will return to normal operation.

Load Transient Considerations:

The SY20121 regulator integrates the compensation components to achieve good stability and fast transient responses. In some applications, adding a

22pF ceramic cap 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.

Layout Design:

The layout design of SY20121 is relatively simple. For the best efficiency and to minimize noise problems, we should place the following components 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 vias 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 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 and OUT pin must NOT be adjacent to the LX net on the PCB layout to avoid the noise problem.

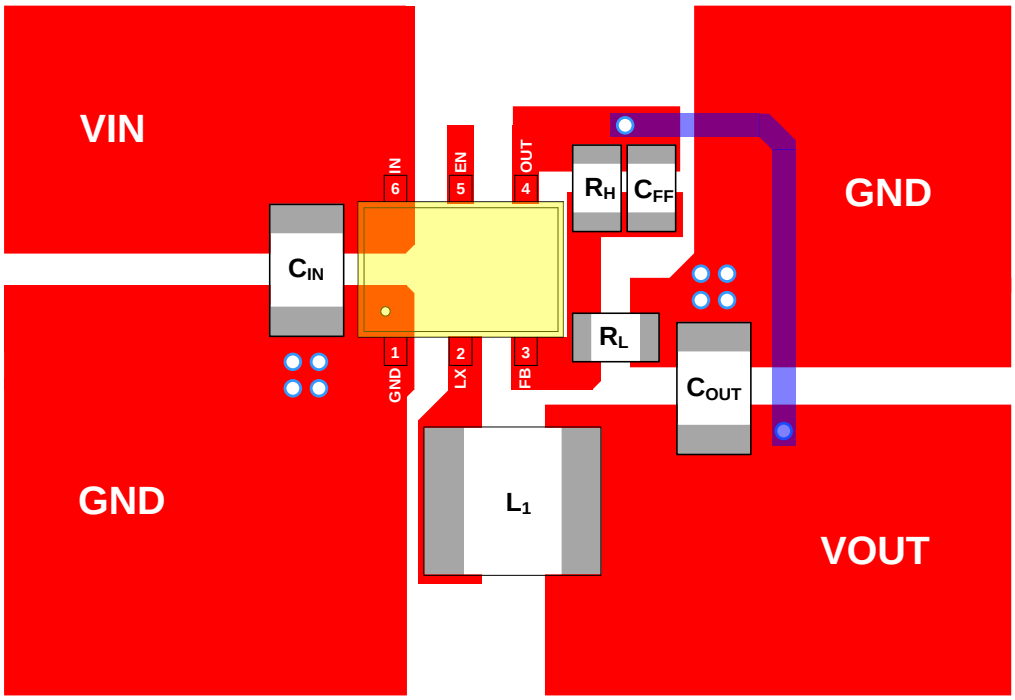
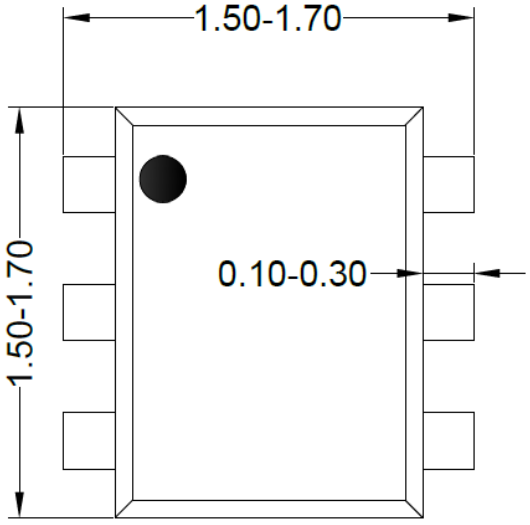
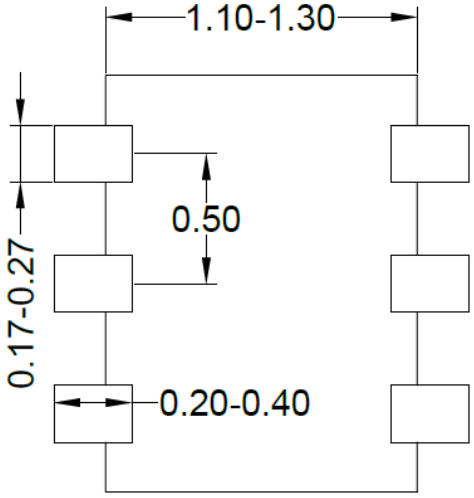


Figure4. PCB Layout Suggestion

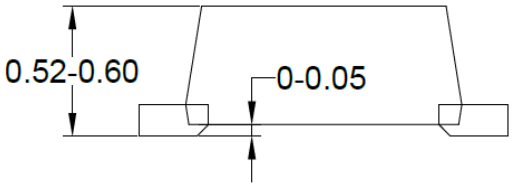
SOT563 Package Outline Drawing



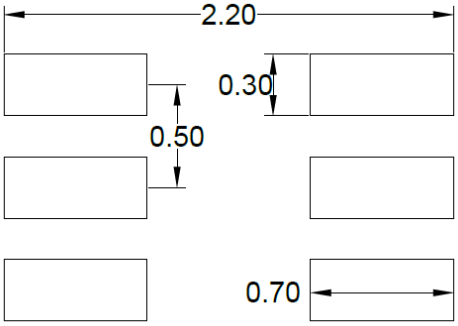
Top view



Bottom view



Side View



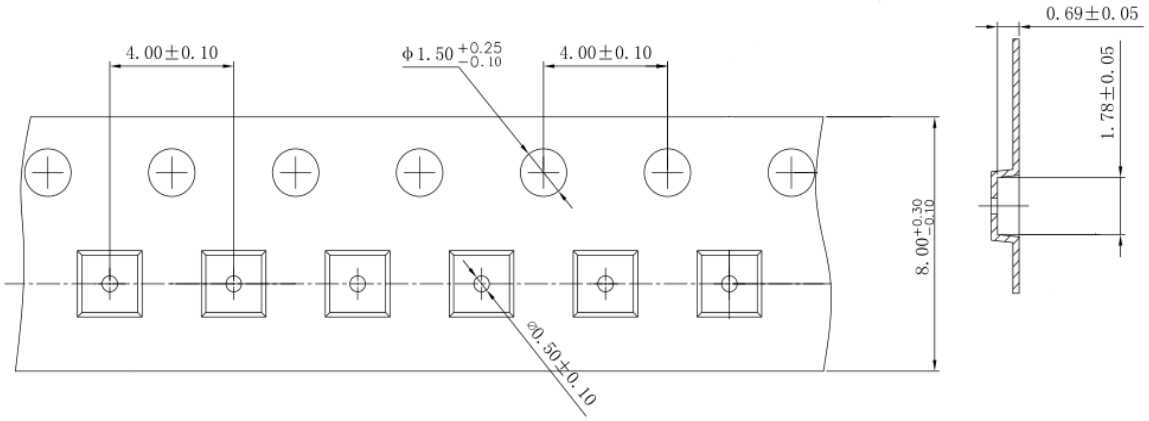
Recommended PCB layout
(Reference only)

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

Taping & Reel Specification

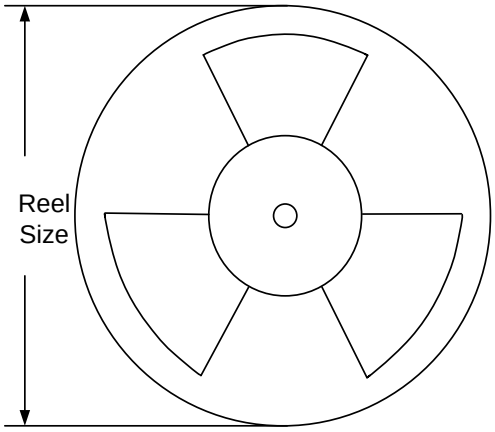
1. Taping Orientation

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

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