



# Application Note: SY8088I

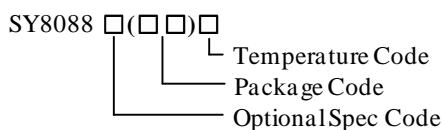
## High Efficiency, 1.5MHz, 1A Synchronous Step Down Regulator Preliminary Specification

### General Description

SY8088I is a high efficiency 1.5MHz synchronous step down DC/DC regulator capable of delivering up to 1A output current. It can operate over a wide input voltage range from 2.5V to 5.5V and integrates main switch and synchronous switch with very low  $R_{DS(ON)}$  to minimize the conduction loss.

The low output voltage ripple, the small external inductor and the capacitor sizes are achieved with 1.5MHz switching frequency.

### Ordering Information



Ordering Number	Package type	Note
SY8088IAAC	SOT23-5	--

### Features

- 2.5V to 5.5V Input Voltage Range
- 50µA Low Quiescent Current
- Low  $R_{DS(ON)}$  for Internal Switches (Top/Bottom) 260mΩ /170mΩ
- High Switching Frequency 1.5MHz Minimizes the External Components
- Internal Soft-start Limits the Inrush Current
- 100% Dropout Operation
- Reliable Short Circuit Protection
- RoHS Compliant and Halogen Free
- Output Auto Discharge Function
- Compact Package: SOT23-5

### Applications

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

### Typical Applications

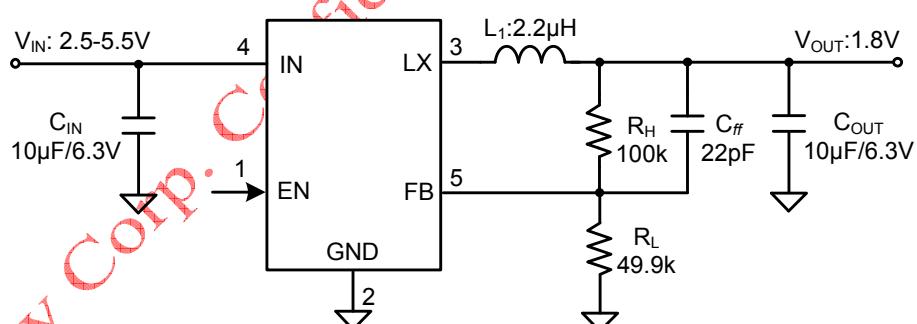
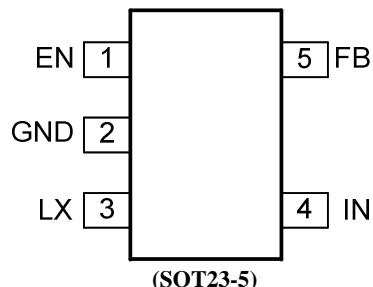


Figure1. Schematic Diagram

## Pinout (Top View)



**Top Mark:** bPx<sub>y</sub>z (device code: bP, x=year code, y=week code, z= lot number code)

Pin Name	Pin Number	Pin Description
EN	1	Enable control. Pull high to turn on. Do not leave it floating.
GND	2	Ground pin.
LX	3	Inductor pin. Connect this pin to the switching node of the inductor.
IN	4	Input pin. Decouple this pin to the GND pin with at least a 10 $\mu$ F ceramic capacitor.
FB	5	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: $V_{OUT}=0.6\times(1+R_H/R_L)$ .

## Block Diagram

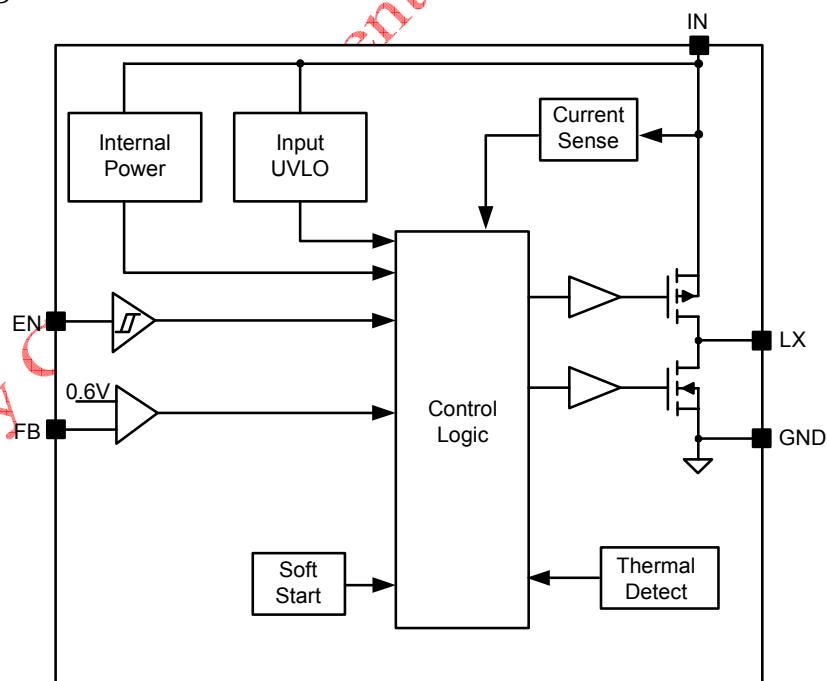


Figure2. Block Diagram

**Absolute Maximum Ratings** (Note 1)

Supply Input Voltage	6.0V
EN, FB Voltage	V <sub>IN</sub> + 0.6V
LX Voltage	-0.3V <sup>(*)1</sup> to 6.0V <sup>(*)2</sup>
Power Dissipation, P <sub>D</sub> @ T <sub>A</sub> = 25°C	0.77W
Package Thermal Resistance (Note 2)	
θ <sub>JA</sub>	130°C/W
θ <sub>JC</sub>	28°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	2.5V to 5.5V
Junction Temperature Range	-40°C to 125°C
Ambient Temperature Range	-40°C to 85°C

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## Electrical Characteristics

( $V_{IN} = 5V$ ,  $V_{OUT} = 1.8V$ ,  $L = 2.2\mu H$ ,  $C_{OUT} = 10\mu F$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	$V_{IN}$		2.5		5.5	V
Input UVLO Threshold	$V_{UVLO}$				2.45	V
Input UVLO Hysteresis	$V_{HYS}$			150		mV
Quiescent Current	$I_Q$	$V_{FB}=V_{REF}\times 105\%$		50	70	$\mu A$
Shutdown Current	$I_{SHDN}$	$V_{EN}=0V$		0.1	1	$\mu A$
Feedback Reference Voltage	$V_{REF}$	$I_{OUT}=0.5A$ , CCM	591	600	609	mV
LX Node Discharge Resistance	$R_{DIS}$			50		$\Omega$
Top FET $R_{ON}$	$R_{DS(ON)1}$			260		$m\Omega$
Bottom FET $R_{ON}$	$R_{DS(ON)2}$					$m\Omega$
EN Input Voltage High	$V_{EN,H}$		1.2			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		300		$\mu s$
Soft-start Time	$t_{SS}$			700		us
Switching Frequency	$f_{SW}$	$I_{OUT}=0.5A$ , CCM		1.5		MHz
Top FET Current Limit	$I_{LMT, TOP}$			1.5	2.5	A
Thermal Shutdown Temperature	$T_{SD}$			160		$^\circ C$
Thermal Shutdown Hysteresis	$T_{HYS}$			20		$^\circ C$

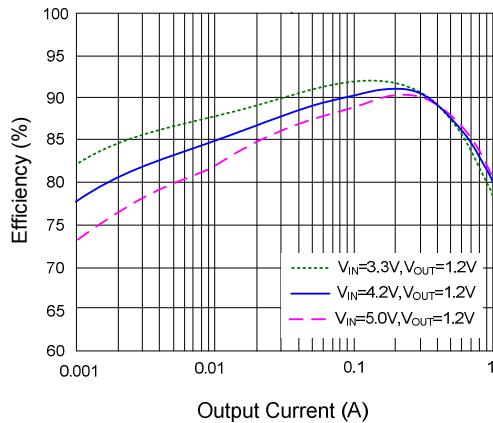
**Note 1:** Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute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

**Note 2:**  $\theta_{JA}$  of SY8088I is measured in the natural convection at  $T_A = 25^\circ C$  on a 2OZ two-layer Silergy evaluation board. Pin 3 is the case position for  $\theta_{JC}$  measurement.

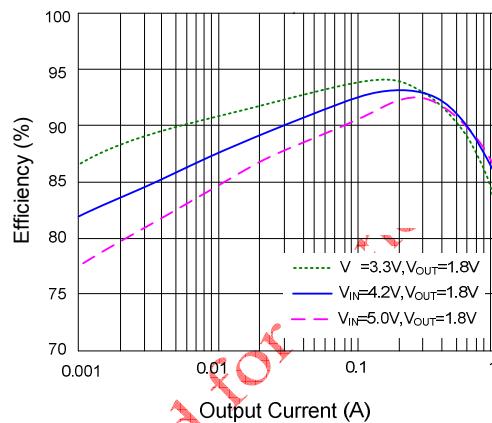
**Note 3:** The device is not guaranteed to function outside its operating conditions.

## Typical Performance Characteristics

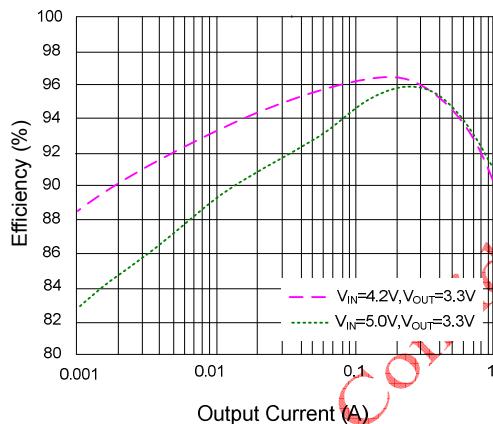
Efficiency vs. Output Current



Efficiency vs. Output Current

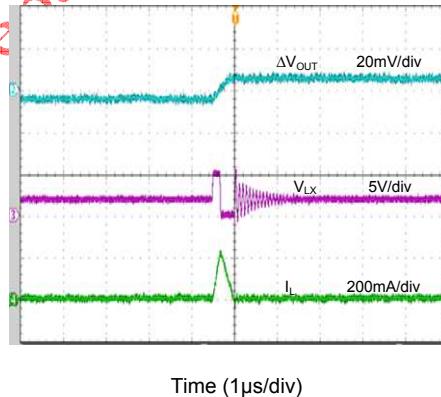


Efficiency vs. Output Current



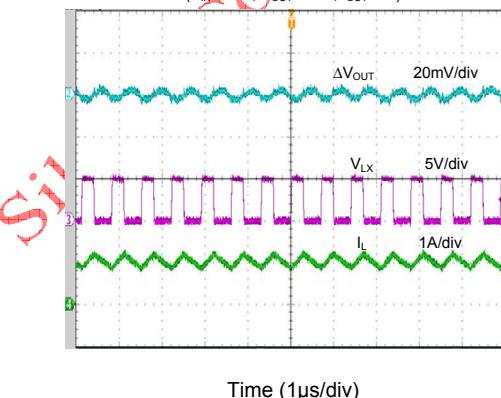
Output Ripple

( $V_{IN}=5.0V, V_{OUT}=1.8V, I_{OUT}=0A$ )



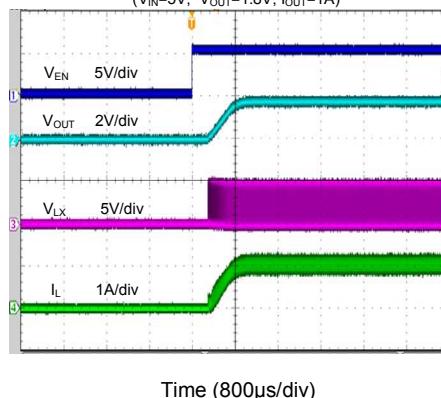
Output Ripple

( $V_{IN}=5.0V, V_{OUT}=1.8V, I_{OUT}=1A$ )



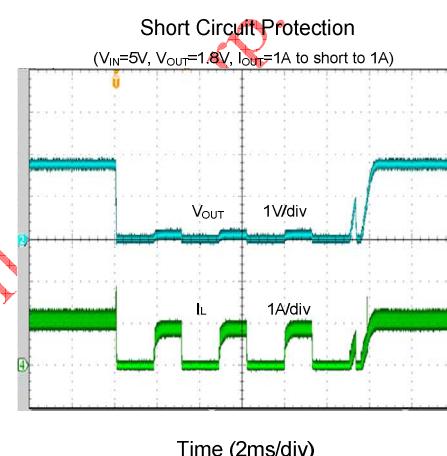
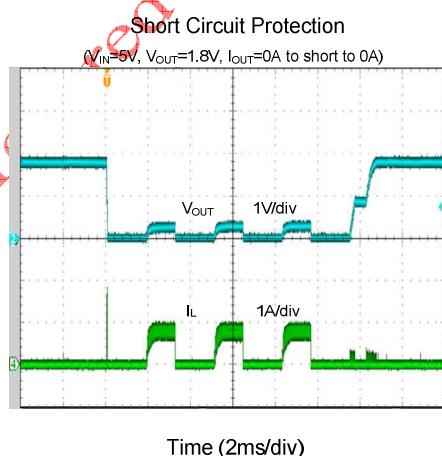
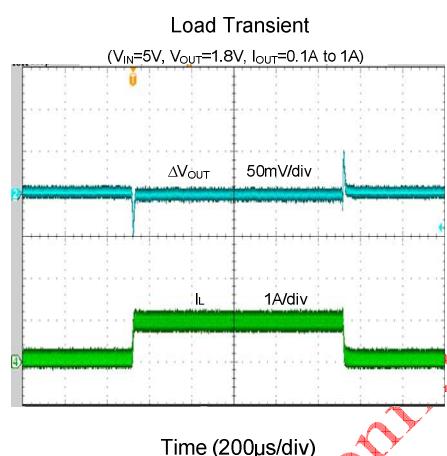
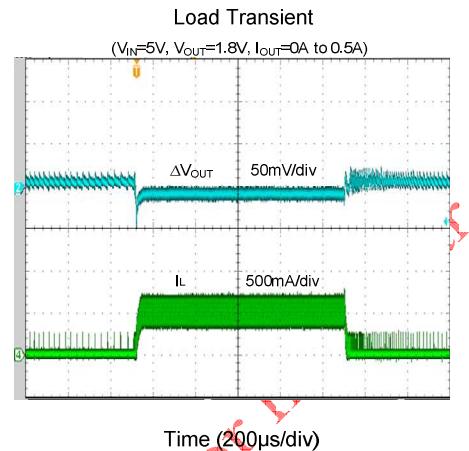
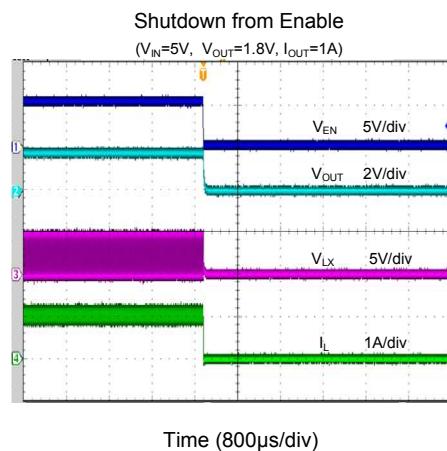
Startup from Enable

( $V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=1A$ )





# AN\_SY8088I





## Operation

SY8088I is a high efficiency 1.5MHz synchronous step down DC/DC regulator capable of delivering up to 1A output current. It can operate over a wide input voltage range from 2.5V to 5.5V and integrates main switch and synchronous switch with very low  $R_{DS(ON)}$  to minimize the conduction loss.

The low output voltage ripple, the small external inductor and the capacitor sizes are achieved with 1.5MHz switching frequency.

## Applications Information

Because of the high integration in the SY8088I, the application circuit based on this regulator is rather simple. Only input capacitor  $C_{IN}$ , output capacitor  $C_{OUT}$ , output inductor L, feedback resistors ( $R_H$  and  $R_L$ ) and feed forward capacitor  $C_{ff}$  need to be selected for the targeted applications 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 100k $\Omega$  and 1M $\Omega$  is highly recommended for both resistors. If  $R_L=100k\Omega$  is chosen, then  $R_H$  can be calculated to be:

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

### Input Capacitor $C_{IN}$ :

A typical X5R or better grade ceramic capacitor with 6.3V rating and no less than 10 $\mu$ F 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 Capacitor $C_{OUT}$ :

The output capacitor is selected to handle the output ripple noise requirements. Both steady state ripple and transient requirements must be taken into consideration when selecting this capacitor. For the best performance, it is recommended to use X5R or better grade ceramic capacitor with 6.3V rating and no less than 10 $\mu$ F 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:

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

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

The SY8088I 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.

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

- 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  $DCR < 50m\Omega$  to achieve a good overall efficiency.

### Short Circuit Protection:

SY8088I integrates hiccup mode hard short protection function. If output voltage is below 50% of the regulation voltage, the internal soft-start node and the error amplifier output will be reset immediately. IC works in hiccup protection mode. The hiccup frequency is about 300Hz, and the hiccup duty is about 45%. If the hard short condition is removed, IC will go back to normal operation.

### Load Transient Considerations:

The SY8088I regulator integrates the compensation components to achieve good stability and fast transient responses. In some applications, adding a ceramic capacitor (feed-forward capacitor,  $C_{ff}$ ) 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. Typically, for 1.2V/1.8V/3.3V output, the  $R_H$ ,  $R_L$ ,  $C_{ff}$  is recommended as below:

**Table1. Recommended Component Selection**

$V_{OUT}$	$R_H$	$R_L$	$C_{ff}$
1.2V	49.9k	49.9k	22pF
1.8V	100k	49.9k	22pF
3.3V	100k	22.1k	22pF

## Layout Design:

The layout design of SY8088I 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,  $R_H$  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 recommended.
- 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 must NOT be adjacent to the LX net on the PCB layout to avoid the noise problem.
- 5) If the system chip interfacing with the EN pin has a high impedance state at shutdown mode and the IN pin is connected directly to a power source such as a Li-Ion battery, it is desirable to add a pull down 1M resistor between the EN and GND pins to prevent the noise from falsely turning on the regulator at shutdown mode.

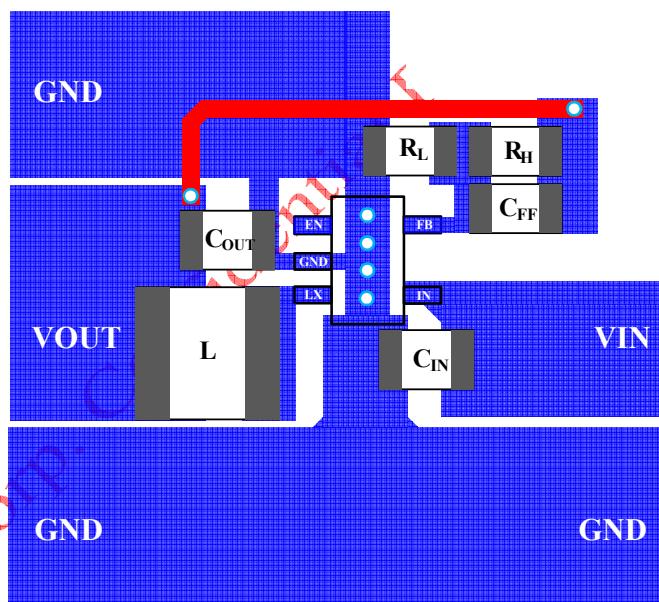
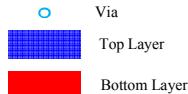
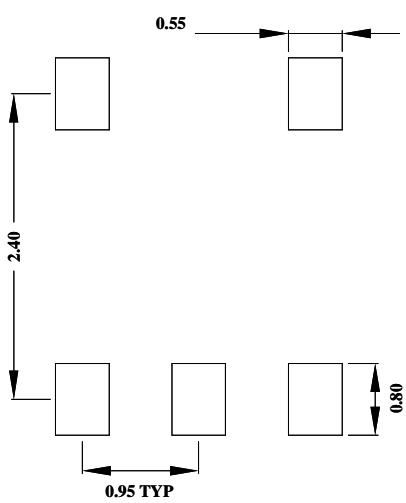
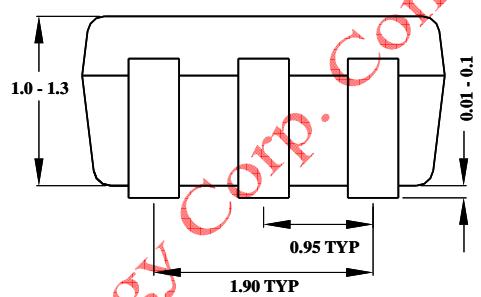
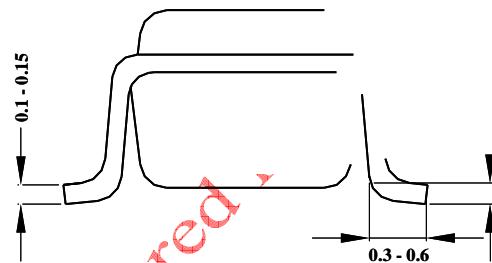
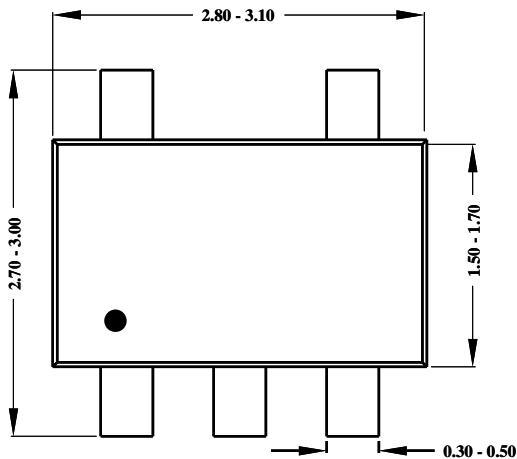


Figure3. PCB Layout Suggestion

## SOT23-5 Package Outline & PCB Layout Design

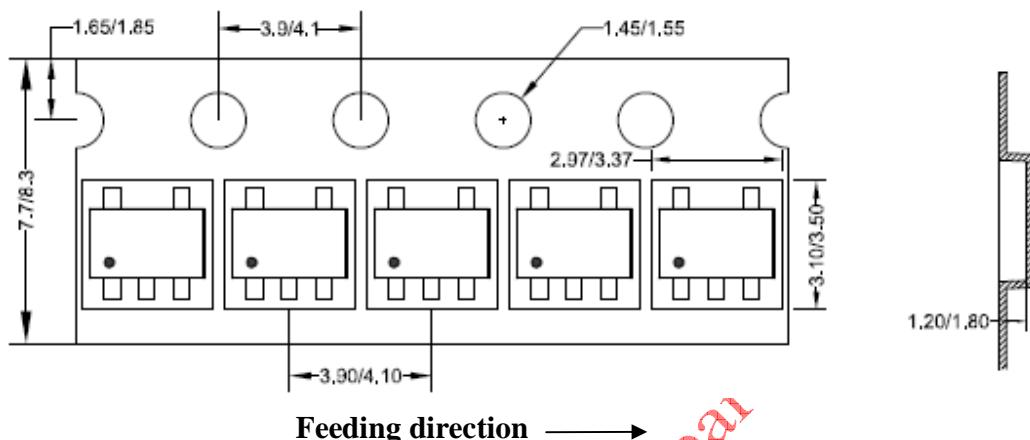


**Notes:** All dimensions are in millimeters.  
All dimensions don't include mold flash & metal burr.

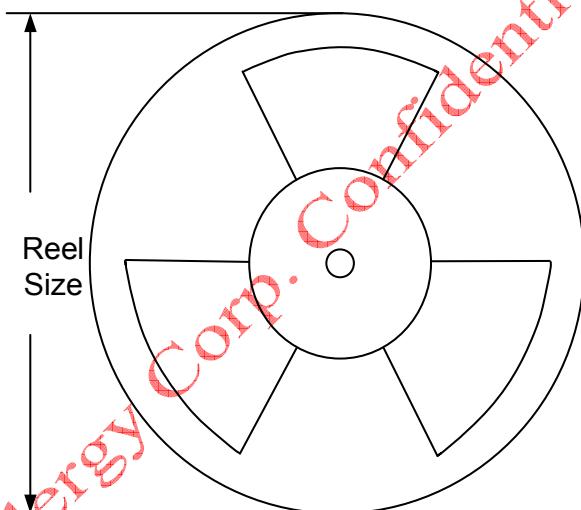
## Taping & Reel Specification

### 1. Taping orientation

**SOT23-5**



### 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

### 3. Others: NA