

## High Efficiency, 300kHz, 36V Input, 1.2A Asynchronous Step Down Regulator

### General Description

The SY21061F is a high efficiency 300kHz, adaptive constant OFF time controlled asynchronous step-down DC/DC regulator capable of delivering 1.2A output current respectively. The SY21061F can operate over a wide input voltage range from 9V to 36V and integrates the main switch with very low  $R_{DS(ON)}$  to minimize the conduction loss.

Low output voltage ripple and small external inductor and capacitor sizes are achieved with 300kHz switching frequency.

### Ordering Information

SY21061 □(□)□□  
 └─ Temperature Code  
 └─ Package Code  
 └─ Optional Spec Code

Ordering Number	Package type	Note
SY21061FABC	SOT23-6	--

### Features

- 9-36V Input Voltage Range
- Low  $R_{DS(ON)}$  for Internal N-channel Power FET: 180 mΩ
- 300kHz Switching Frequency
- Adaptive Constant OFF Time Control
- Internal Soft-start Limits the Inrush Current
- 2% 0.81V Reference
- RoHS Compliant and Halogen Free
- Compact Package: SOT23-6

### Applications

- Set Top Box
- Portable TV
- Access Point Router
- DSL Modem
- LCD TV

### Typical Applications

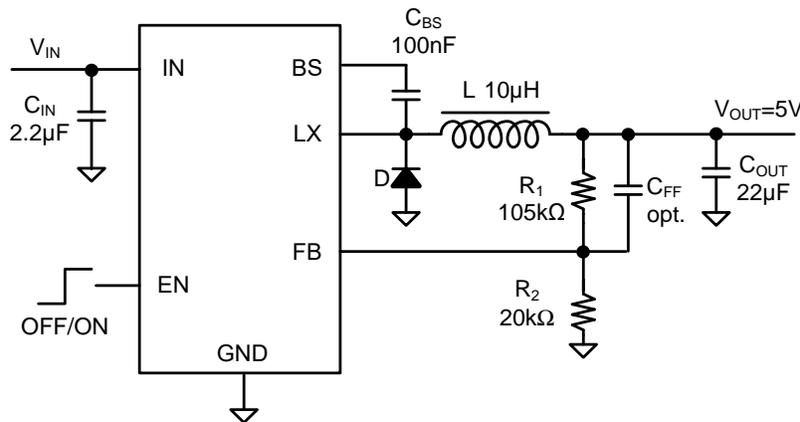
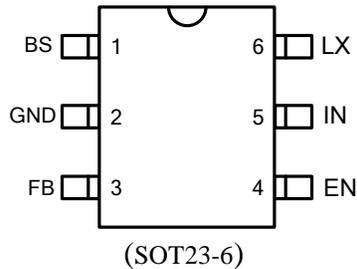


Figure1. Schematic Diagram

**Pinout** (top view)



Top Mark: qRxyz (Device code: qR, x=year code, y=week code, z=lot number code)

Pin Name	Pin Number	Pin Description
BS	1	Boot-strap pin. Supply high side gate driver. Decouple this pin to the LX pin with a 0.1μF ceramic capacitor.
GND	2	Ground pin.
FB	3	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: $V_{OUT}=0.81 \times (1+R_1/R_2)$
EN	4	Enable control. Pull high or leave this pin floating to turn on the IC, pull low to turn off the IC.
IN	5	Input pin. Decouple this pin to the GND pin with at least a 2.2μF ceramic capacitor.
LX	6	Inductor pin. Connect this pin to the switching node of the inductor.

**Absolute Maximum Ratings** (Note 1)

Supply Input Voltage	-0.3V to 40V
EN Voltage	-0.3V to $V_{IN}+0.6V$
FB, BS-LX Voltage	-0.3V to 3.6V
LX Voltage	-0.7V to $V_{IN} + 0.6V$
Power Dissipation, $P_D$ @ $T_A = 25^\circ C$ , SOT23-6	0.6W
Package Thermal Resistance (Note 2)	
$\theta_{JA}$	170°C/W
$\theta_{JC}$	130°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
Dynamic LX voltage in 20ns Duration	$IN+3V$ to $GND-5V$

**Recommended Operating Conditions** (Note 3)

Supply Input Voltage	9V to 36V
Junction Temperature Range	-40°C to 125°C

## Electrical Characteristics

( $V_{IN} = 12V$ ,  $V_{OUT} = 5V$ ,  $L = 10\mu H$ ,  $C_{OUT} = 22\mu F$ ,  $T_A = 25^\circ C$ ,  $I_{OUT} = 0.5A$  unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	$V_{IN}$		9		36	V
Input UVLO Threshold	$V_{UVLO}$	Rising	7.5	8	8.5	V
Input UVLO Threshold		Falling	5.5	6	6.5	V
Input UVLO Hysteresis	$V_{UVLO\_HYS}$			2		V
Quiescent Current	$I_Q$	$I_{OUT}=0$ , $V_{FB}=V_{REF}\times 105\%$		160		$\mu A$
Shutdown Current	$I_{SHDN}$	$EN=0$			10	$\mu A$
Feedback Reference Voltage	$V_{REF}$		0.794	0.81	0.826	V
FB Input Current	$I_{FB}$	$V_{FB}=3V$	-50		50	nA
Power FET RON	$R_{DS(ON)1}$			180		m $\Omega$
Power FET Current Limit	$I_{LIM}$	$V_{FB}=V_{REF}\times 98\%$	1.5		2.2	A
EN Rising Threshold	$V_{ENH}$		1.5			V
EN Falling Threshold	$V_{ENL}$				0.4	V
Minimum OFF Time	$t_{OFF}$				100	ns
Minimum ON Time	$t_{OFF}$				100	ns
Soft-start Time	$t_{SS}$			650		$\mu s$
Oscillator Frequency	$f_{OSC}$		240	300	360	kHz
Thermal Shutdown Temperature	$T_{SD}$			150		$^\circ C$
Thermal Shutdown Recovery Hysteresis	$T_{HYS}$			50		$^\circ C$

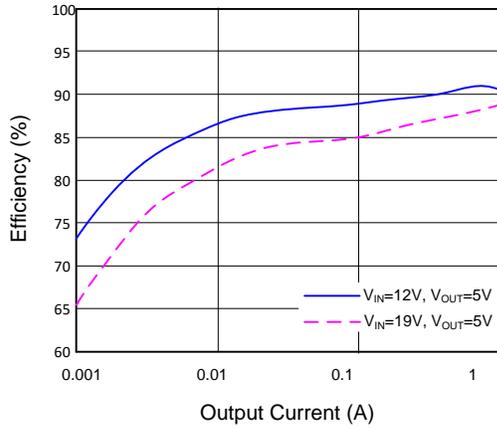
**Note 1:** Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute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

**Note 2:**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ C$  on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

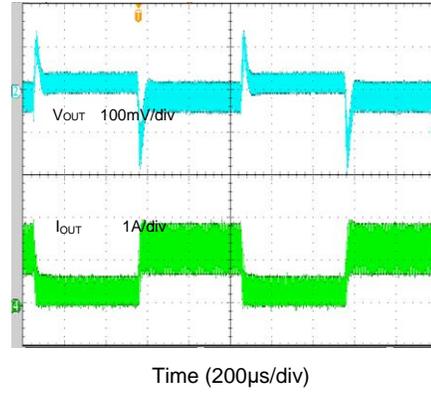
**Note 3:** The device is not guaranteed to function outside its operating conditions.

## Typical Performance Characteristics

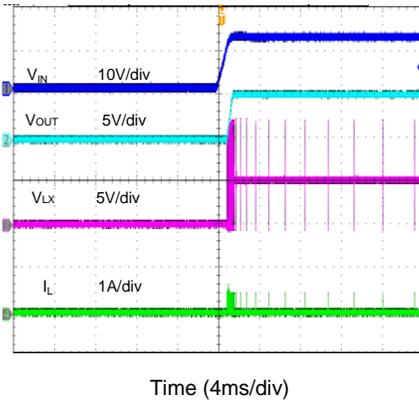
Efficiency vs Output Current



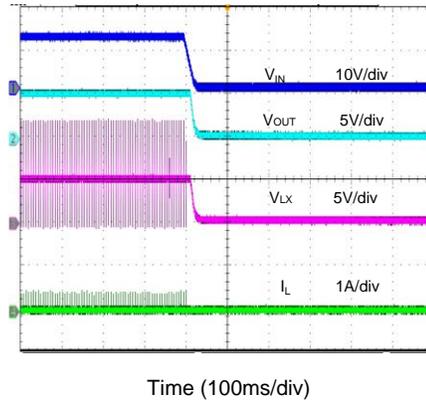
Load Transient Response  
( $V_{IN}=12V, V_{OUT}=5V, I_{OUT}=0.12-1.2A$ )



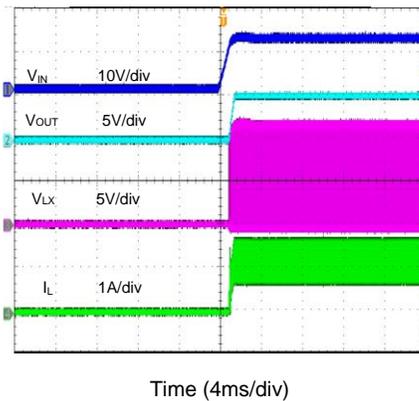
Startup from  $V_{IN}$   
( $V_{IN}=12V, V_{OUT}=5V, I_{OUT}=0A$ )



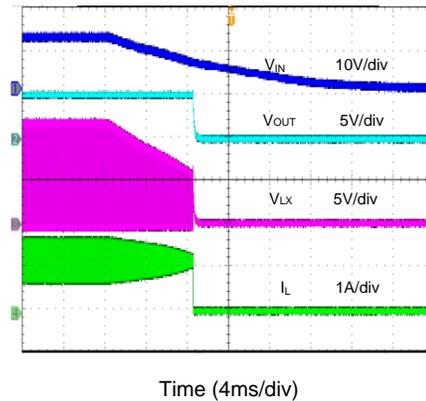
Shutdown from  $V_{IN}$   
( $V_{IN}=12V, V_{OUT}=5V, I_{OUT}=0A$ )



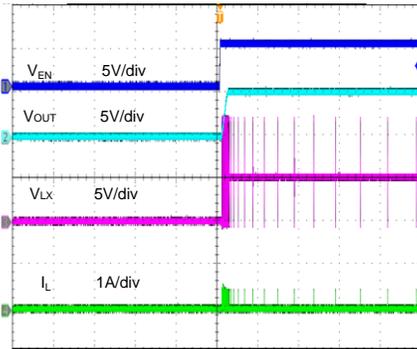
Startup from  $V_{IN}$   
( $V_{IN}=12V, V_{OUT}=5V, I_{OUT}=1.2A$ )



Shutdown from  $V_{IN}$   
( $V_{IN}=12V, V_{OUT}=5V, I_{OUT}=1.2A$ )

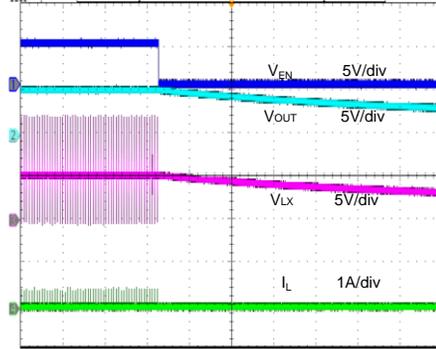


Startup from Enable  
( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=0A$ )



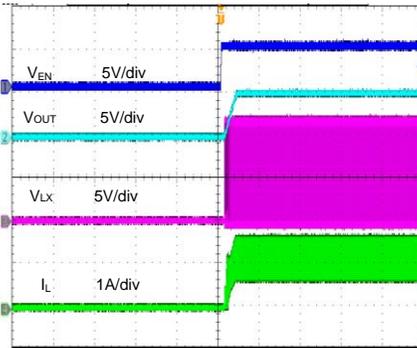
Time (4ms/div)

Shutdown from Enable  
( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=0A$ )



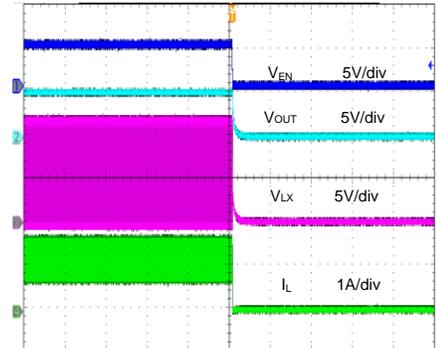
Time (100ms/div)

Startup from Enable  
( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=1.2A$ )



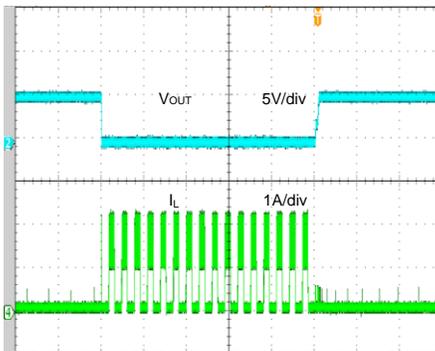
Time (2ms/div)

Shutdown from Enable  
( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=1.2A$ )



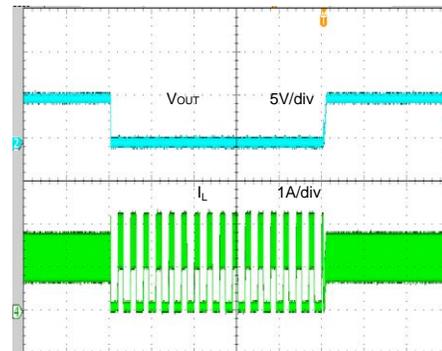
Time (2ms/div)

Short Circuit Protection  
( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=0A$ -short)



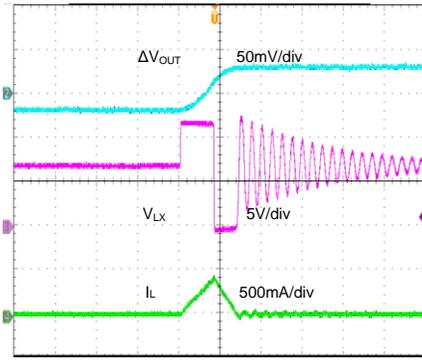
Time (10ms/div)

Short Circuit Protection  
( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=1.2A$ -short)



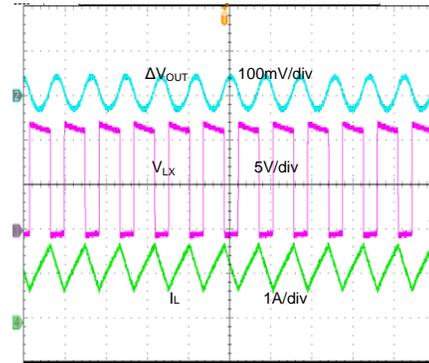
Time (10ms/div)

Output Voltage Ripple  
 ( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=0A$ )



Time (1 $\mu$ s/div)

Output Voltage Ripple  
 ( $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $I_{OUT}=1.2A$ )



Time (4 $\mu$ s/div)

## Operation

The SY21061F is an asynchronous Buck regulator that integrates the PWM control, a main switch on the same die. With ultra low  $R_{DS(ON)}$  power switch and proprietary PWM control, this regulator can achieve high efficiency and fast transient response. High switch frequency minimizes the external inductor and capacitor size, thus minimizes the PCB area and the cost. The SY21061F also features cycle by cycle current limit, output short circuit protection and thermal shutdown protection.

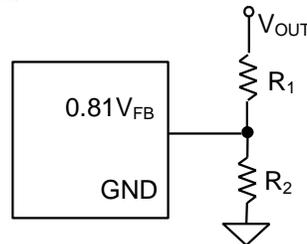
## Applications Information

Because of the high integration in the SY21061F, the application circuit based on this regulator is rather simple. Only the input capacitor  $C_{IN}$ , the output capacitor  $C_{OUT}$ , the output inductor  $L$ , the rectifier diode  $D$  and the feedback resistors ( $R_1$  and  $R_2$ ) need to be selected for the targeted applications.

### Feedback Resistor Dividers $R_1$ and $R_2$ :

Choose  $R_1$  and  $R_2$  to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both  $R_1$  and  $R_2$ . A value of between  $10k\Omega$  and  $1M\Omega$  is highly recommended for both resistors. If  $V_{OUT}$  is 5V,  $R_1=105k\Omega$  is chosen, then using the following equation,  $R_2$  can be calculated to be  $20k\Omega$ :

$$R_2 = \frac{0.81V}{V_{OUT} - 0.81V} R_1$$



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

The ripple current through the input capacitor is calculated as:

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

To minimize the potential noise problem, a typical X5R or better grade ceramic capacitor should be placed really close to the IN pin and the negative end of the rectifier. A low ESR ceramic capacitor is recommended with greater than  $2.2\mu F$  capacitance.

### 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 an X5R or better grade ceramic capacitor with greater than  $22\mu F$  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 SY21061F 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.

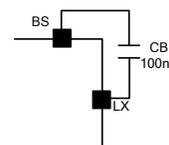
- 2) The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions.

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

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

### External Bootstrap Capacitor

This capacitor provides the gate driver voltage for internal high side MOSFET. A  $100nF$  low ESR ceramic capacitor connected between the BS pin and the LX pin is recommended.



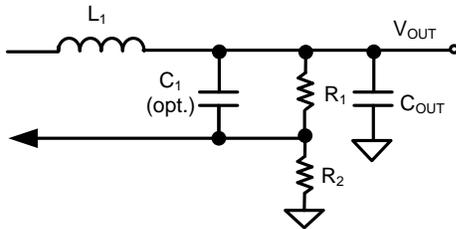
### Rectifier Diode



Because of high switching speed of the SY21061F, a Schottky diode with low forward voltage and fast switching speed is desirable for the application. The voltage rating of the diode must be higher than the maximum output voltage. The diode's average and peak current rating should exceed the average output current and peak current.

**Load Transient Considerations:**

The SY21061F integrates the compensation components to achieve good stability and fast transient responses. In some applications, adding a small ceramic capacitor in parallel with R<sub>1</sub> may further speed up the load transient response and is it is recommended for high step load applications.



**Layout Design:**

The layout design of the SY21061F is relatively simple. For the best efficiency and minimum noise problem, the following components should be placed close to the IC: C<sub>IN</sub>, L, R<sub>1</sub> and R<sub>2</sub>.

- 1) It is desirable to maximize the PCB copper area connecting to the GND pin to achieve the best thermal and noise performance. If the board space allowed, a ground plane is highly desirable.
- 2) The loop area formed by IN, LX, C<sub>IN</sub> and the rectifier 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<sub>1</sub> and R<sub>2</sub> 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, it is desirable to add a pull-down 1MΩ resistor between the EN and the GND pins to prevent the noise from falsely turning on the regulator at shutdown mode.

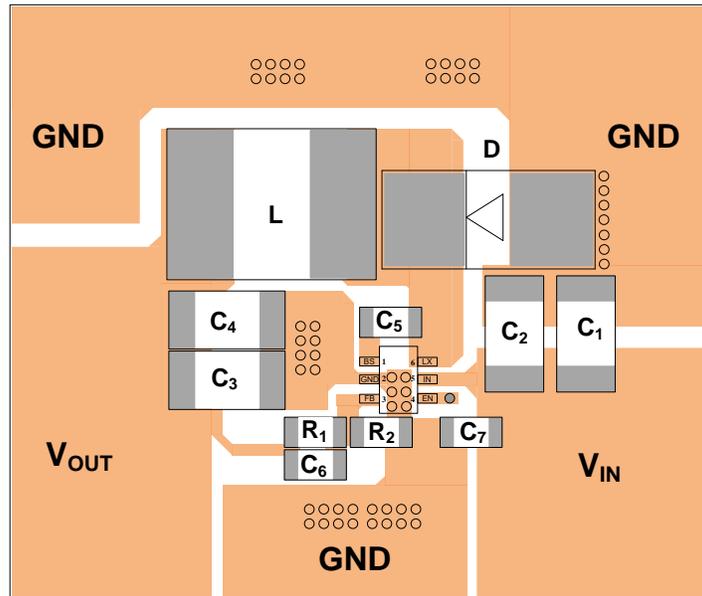
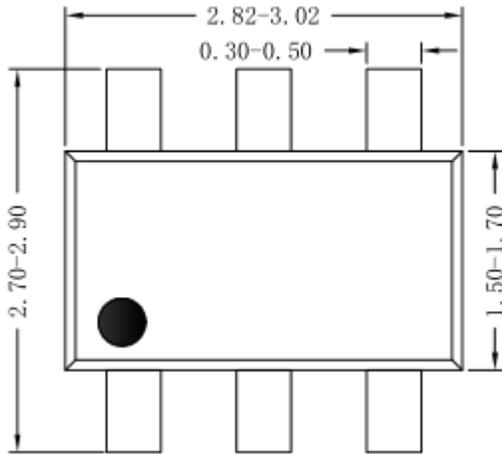
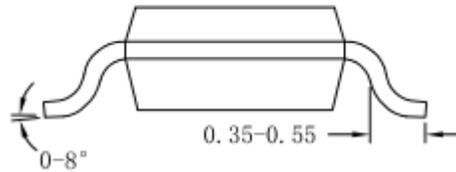


Figure3. PCB Layout Suggestion

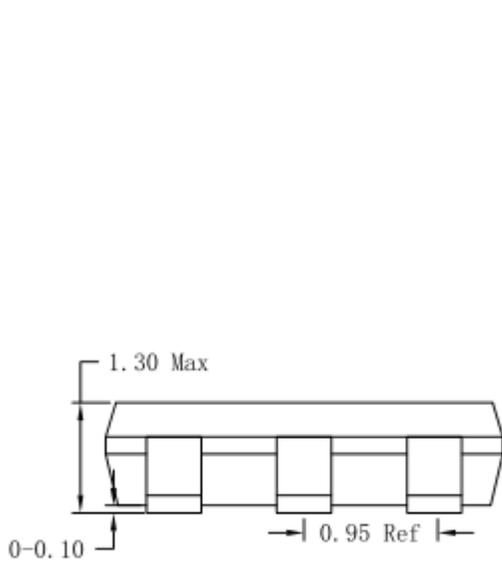
**SOT23-6 Package Outline & PCB Layout Design**



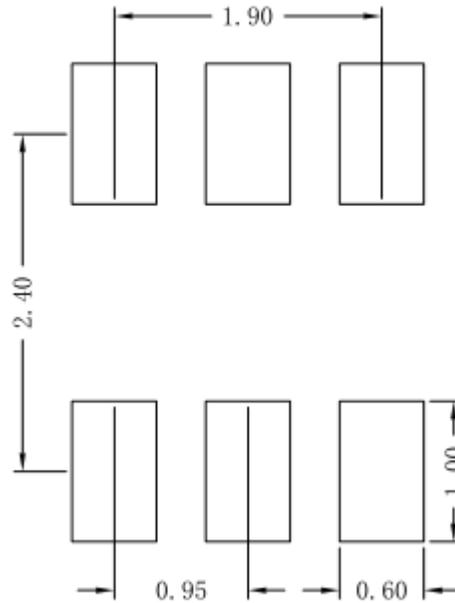
**Top View**



**Side View**



**Side View**

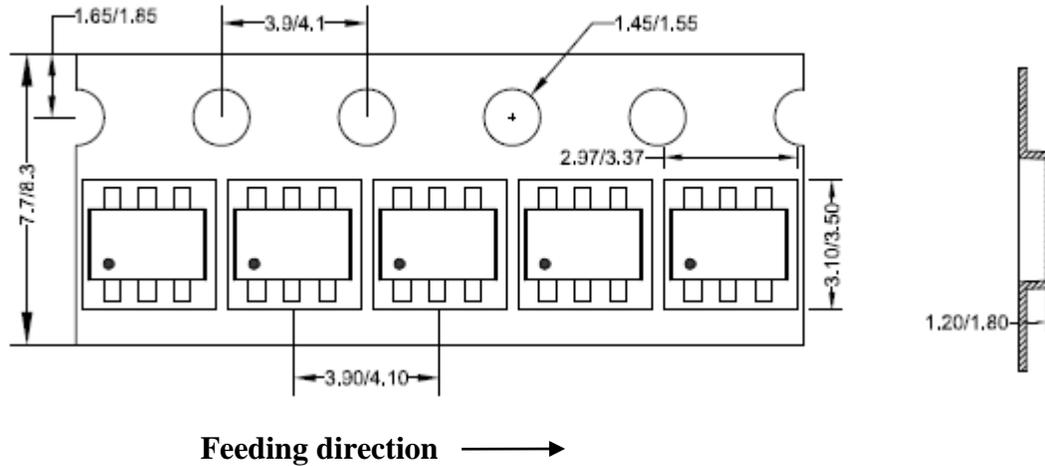


**Recommended Pad Layout**

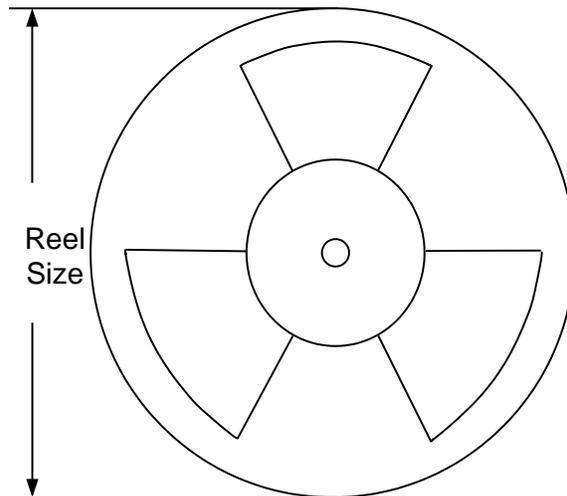
**Notes: All dimension in millimeter and exclude mold flash & metal burr.**

**Taping & Reel Specification**

**1. Taping orientation for package**



**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
SOT23-6	8	4	7"	280	160	3000

**3. Others: NA**



## IMPORTANT NOTICE

- 1. Right to make changes.** Silergy and its subsidiaries (hereafter Silergy) reserve the right to change any information published in this document, including but not limited to circuitry, specification and/or product design, manufacturing or descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to Silergy's standard terms and conditions of sale.
- 2. Applications.** Application examples that are described herein for any of these products are for illustrative purposes only. Silergy makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification. Buyers are responsible for the design and operation of their applications and products using Silergy products. Silergy or its subsidiaries assume no liability for any application assistance or designs of customer products. It is customer's sole responsibility to determine whether the Silergy product is suitable and fit for the customer's applications and products planned. To minimize the risks associated with customer's products and applications, customer should provide adequate design and operating safeguards. Customer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Silergy assumes no liability related to any default, damage, costs or problem in the customer's applications or products, or the application or use by customer's third-party buyers. Customer will fully indemnify Silergy, its subsidiaries, and their representatives against any damages arising out of the use of any Silergy components in safety-critical applications. It is also buyers' sole responsibility to warrant and guarantee that any intellectual property rights of a third party are not infringed upon when integrating Silergy products into any application. Silergy assumes no responsibility for any said applications or for any use of any circuitry other than circuitry entirely embodied in a Silergy product.
- 3. Limited warranty and liability.** Information furnished by Silergy in this document is believed to be accurate and reliable. However, Silergy makes no representation or warranty, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. In no event shall Silergy be liable for any indirect, incidental, punitive, special or consequential damages, including but not limited to lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges, whether or not such damages are based on tort or negligence, warranty, breach of contract or any other legal theory. Notwithstanding any damages that customer might incur for any reason whatsoever, Silergy' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Standard Terms and Conditions of Sale of Silergy.
- 4. Suitability for use.** Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of Silergy components in its applications, notwithstanding any applications-related information or support that may be provided by Silergy. Silergy products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an Silergy product can reasonably be expected to result in personal injury, death or severe property or environmental damage. Silergy assumes no liability for inclusion and/or use of Silergy products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.
- 5. Terms and conditions of commercial sale.** Silergy products are sold subject to the standard terms and conditions of commercial sale, as published at <http://www.silergy.com/stdterms>, unless otherwise agreed in a valid written individual agreement specifically agreed to in writing by an authorized officer of Silergy. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. Silergy hereby expressly objects to and denies the application of any customer's general terms and conditions with regard to the purchase of Silergy products by the customer.
- 6. No offer to sell or license.** Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights. Silergy makes no representation or warranty that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right. Information published by Silergy regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from Silergy under the patents or other intellectual property of Silergy.

For more information, please visit: [www.silergy.com](http://www.silergy.com)

© 2019 Silergy Corp.

All Rights Reserved.