SGM3206
Unregulated 60mA Charge Pump Voltage Inverter

GENERAL DESCRIPTION

The SGM3206 is a charge pump voltage inverter that is designed for operating over an input voltage range of 1.4V to 5.5V. The SGM3206 can provide up to 60mA output current. The typical conversion efficiency exceeds 85% over a wide range of output current. The fixed switching frequency is 47kHz. The wide supply voltage is well suited for various applications powered by a 1-cell Li-Ion battery, as well as 2-cell or 3-cell NiCd, NiMH or Alkaline batteries.

This device requires one flying capacitor and two small bypass capacitors for a complete charge pump inverter, making it ideal for numerous battery-powered and board level applications.

The SGM3206 is available in a Green SOT-23-5 package. It operates over an ambient temperature range of -40℃ to +125℃.

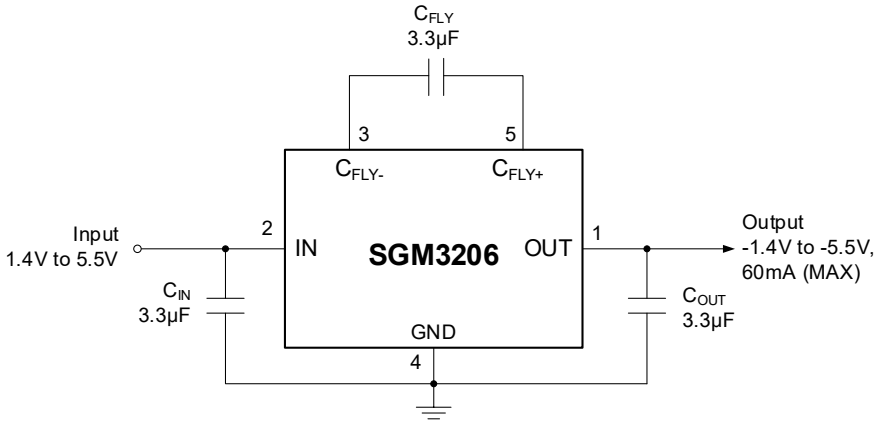
FEATURES

- **Input Voltage Range: 1.4V to 5.5V**
- **Inverts Input Supply Voltage**
- **Output Current: 60mA**
- **Quiescent Current: 115μA (TYP)**
- **Integrated Active Schottky Diode for Startup into Load**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green SOT-23-5 Package**

APPLICATIONS

LCD Bias
Bipolar Amplifier Supply
GaAs Bias for RF Power Amplifier

TYPICAL APPLICATION

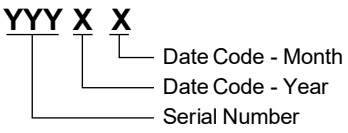


PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM3206	SOT-23-5	-40℃ to +85℃	SGM3206YN5G/TR	SL7XX	Tape and Reel, 3000
	SOT-23-5	-40℃ to +125℃	SGM3206XN5G/TR	SL7XX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XX = Date Code.



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

Voltage Range
IN to GND ..... -0.3V to 6V
OUT to GND ..... -6V to 0.3V
C_{FLY-} to GND ..... 0.3V to V_{OUT} - 0.3V
C_{FLY+} to GND ..... -0.3V to V_{IN} + 0.3V
Continuous Output Current 100mA
Package Thermal Resistance
SOT-23-5, θ_{JA} ..... 183.3℃/W
SOT-23-5, θ_{JB} ..... 72.3℃/W
SOT-23-5, θ_{JC} ..... 116.5℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 8000V
MM 400V

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range ..... -40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

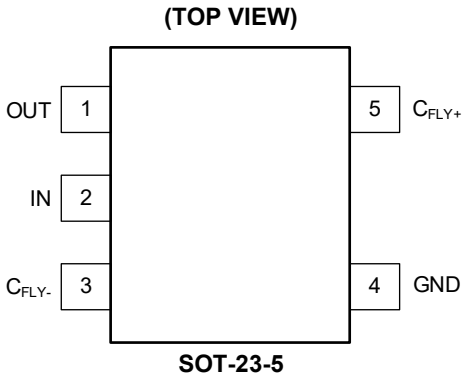
ESD SENSITIVITY CAUTION

This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATION



PIN DESCRIPTION

PIN	NAME	FUNCTION
1	OUT	Power Output Pin. It is recommended that the filter capacitor C_{OUT} bypass OUT to GND.
2	IN	Power Input Pin. A ceramic bypass capacitor that has the same value as the flying capacitor to GND is recommended.
3	C_{FLY-}	Flying Capacitor Negative Terminal.
4	GND	Ground.
5	C_{FLY+}	Flying Capacitor Positive Terminal.

ELECTRICAL CHARACTERISTICS

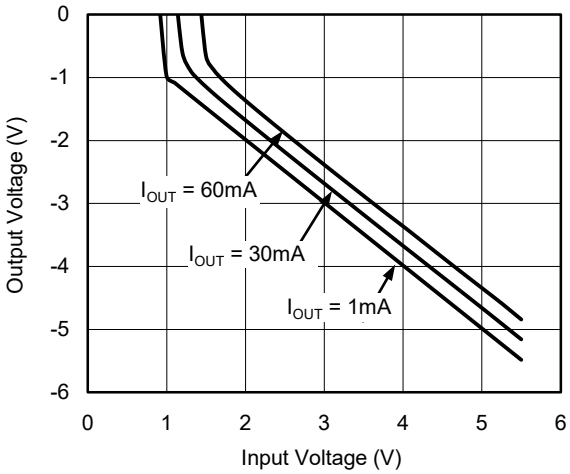
(C_{IN} = C_{FLY} = C_{OUT} = 3.3μF, V_{IN} = 5V. Typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}	R_L = 5kΩ	-40℃ to +125℃	1.4		5.5	V
Maximum Output Current Range at OUT	I_{OUT}		-40℃ to +125℃	60			mA
Output Voltage	V_{OUT}		+25℃		$-V_{IN}$		V
Output Voltage Ripple	V_{PP}	I_{OUT} = 5mA	+25℃		30		mV_{P-P}
Quiescent Current (No Load Input Current)	I_Q		+25℃		115	135	μA
			-40℃ to +85℃			166	
			-40℃ to +125℃			300	
Internal Switching Frequency	f_{OSC}		+25℃	38	47	57	kHz
			-40℃ to +125℃	35		60	
Impedance		I_{OUT} = 30mA	+25℃		10	13	Ω
			-40℃ to +85℃			15	
			-40℃ to +125℃			16.5	

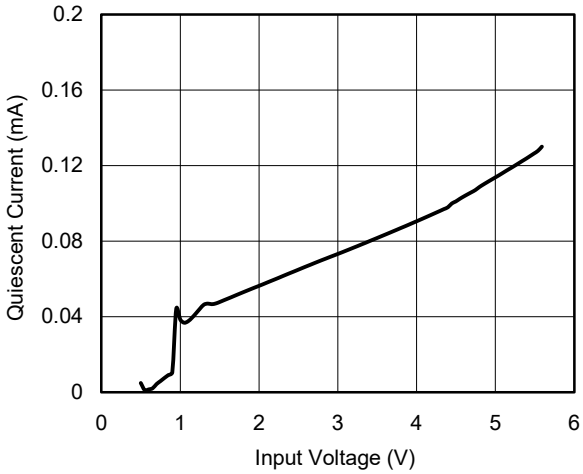
TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN} = C_{FLY} = C_{OUT} = 3.3μF, T_A = +25℃, unless otherwise noted.

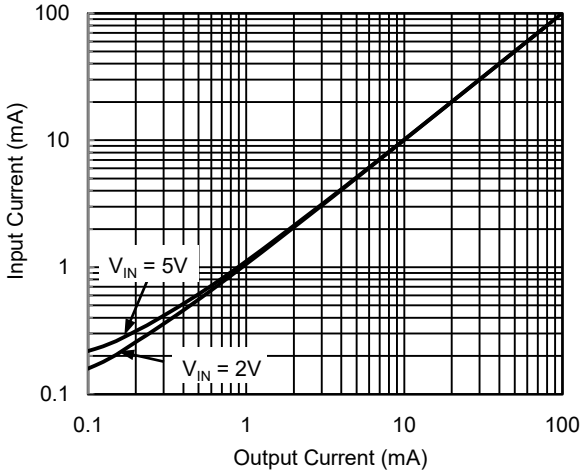
Output Voltage vs. Input Voltage



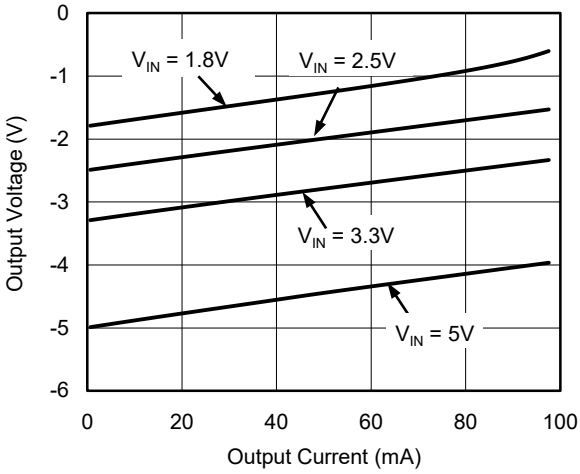
Quiescent Current vs. Input Voltage



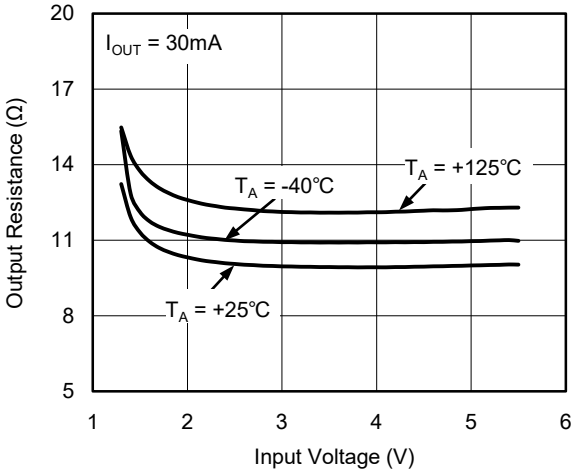
Input Current vs. Output Current



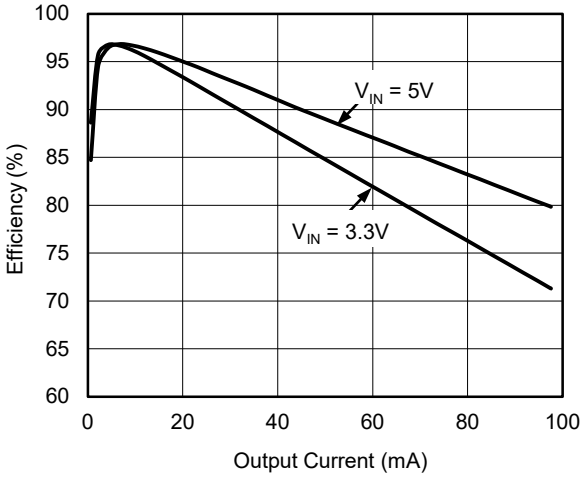
Output Voltage vs. Output Current



Output Resistance vs. Input Voltage



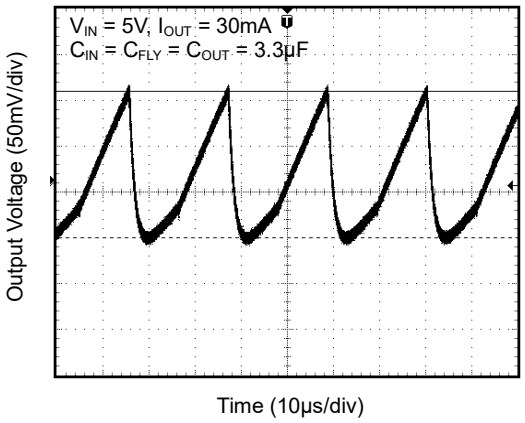
Efficiency vs. Output Current



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, unless otherwise noted.

Output Voltage vs. Time



DETAILED DESCRIPTION

Operating Principle

The SGM3206 is a fully integrated charge pump capable of providing a negative output voltage from a positive input voltage. Figure 1 below illustrates the internal switches to regulate the output voltage. In the first phase of operation, switches S1 and S3 turn on to charge the capacitor C_{FLY} to the input voltage V_{IN}. During the next phase, switches S2 and S4 turn on, the positive terminal of C_{FLY} is connected to ground, and the negative terminal of C_{FLY} is connected to the negative output. The internal switches' alternating operation creates a negative voltage across the output capacitor. Due to the resistance of internal switches and output loading effect, the actual output voltage is more positive than $-V_{IN}$. Low ESR ceramic capacitors are recommended for the C_{FLY} and C_{OUT}.

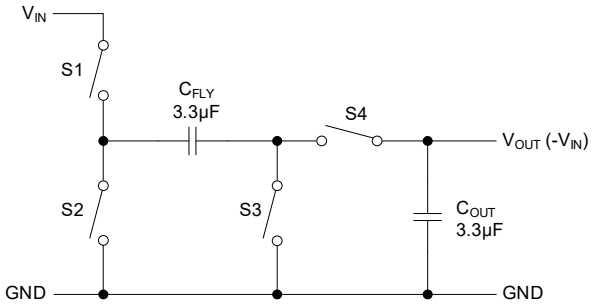


Figure 1. Operating Principle

Charge Pump Output Resistance

The SGM3206 has an output source resistance of 10Ω. When load is applied at the output, the negative output voltage will become less negative or droop towards ground. Equation below calculates the output voltage.

$$V_{OUT} = -(V_{IN} - R_{OUT} \times I_{OUT})$$

$$R_{OUT} \approx \frac{1}{f_{OSC} \times C_{FLY}} + 4\left(2R_{SWITCH} + ESR_{CFLY}\right) + ESR_{COUT}$$

where:

R_{OUT} = output resistance of the converter

R_{SWITCH} = resistance of single internal switch

f_{OSC} = oscillator frequency

Efficiency Considerations

The SGM3206 creates an unregulated negative output voltage based on the input voltage. The device's internal loss to maintain regulation, ESR resistive loss of the capacitor and conversion loss of transferring charge between the capacitors contribute to the operation efficiency. The relationship between these losses and the output resistance is shown below:

$$P_{CAPACITOR\ LOSSES} + P_{CONVERSION\ LOSSES} = I_{OUT}^2 \times R_{OUT}$$

The conversion loss occurs during charge transfer from C_{FLY} to C_{OUT} when there is a voltage potential between these two capacitors. The capacitor loss associates with the effective resistance from an ideal switched-capacitor circuit.

$$P_{CONVERSION\ LOSS} = \left[\frac{1}{2} \times C_{FLY}\left(V_{IN}^2 - V_{OUT}^2\right) + \frac{1}{2} C_{OUT}\left(V_{RIPPLE}^2 - 2V_{OUT}V_{RIPPLE}\right)\right] \times f_{OSC}$$

At light load, the conversion efficiency is dominated by the device's internal power consumption or I_Q. At heavy load, the efficiency is dominated by the effective output resistance R_{OUT}.

$$\eta \cong \frac{I_{OUT}}{I_{OUT} + I_Q}\left(1 - \frac{I_{OUT} \times R_{OUT}}{V_{IN}}\right)$$

DETAILED DESCRIPTION (continued)

Capacitor Selection

Low ESR output capacitor is recommended to reduce the output voltage drop. The ESR of C_{FLY} and C_{OUT} contributes to the output resistance, thus reducing the ESR reduces the output resistance. The output capacitor serves as an energy storage element when the output is loaded. In addition, the output capacitor filters out the switching ripple. Table 1 below lists the recommended capacitor selection when the load current is 60mA.

Table 1. Recommended Capacitor Values

V_{IN} (V)	I_{OUT} (mA)	C_{IN} (μF)	C_{FLY} (μF)	C_{OUT} (μF)
1.4 to 5.5	60	3.3	3.3	3.3

Input Capacitor (C_{IN})

When the device is loaded, the device draws twice the output current from the input. In addition to the recommended input capacitor in Table 1, a 0.1μF bypass capacitor is recommended to place in between the input pin of SGM3206 to ground.

Flying Capacitor (C_{FLY})

Larger capacitance used for C_{FLY} reduces the output resistance, which has a positive effect on output voltage regulation. However, C_{FLY} cannot be increased infinitely since the internal switch's resistance and output capacitor's ESR will become more dominant.

Output Capacitor (C_{OUT})

Larger capacitance used for C_{OUT} reduces the output resistance as well as output voltage ripple. For application can tolerate higher output voltage ripple and load current is small, smaller C_{OUT} can be used. Use equation below to calculate the output peak-to-peak ripple.

$$V_{OUT\ RIPPLE} = \frac{I_{OUT}}{f_{OSC} \times C_{OUT}} + 2 \times I_{OUT} \times ESR_{COUT}$$

APPLICATION INFORMATION

Voltage Inverter

Figure 2 below illustrates a typical circuit of SGM3206 to create a negative voltage from a positive input. The device only requires three external ceramic capacitors to realize 5V to -5V conversion up to 60mA load current.

For best performance and higher output load current capability, ceramic capacitor with higher than 3.3μF is recommended. Lower than 3.3μF output capacitor and flying capacitor used will reduce the load current capability.

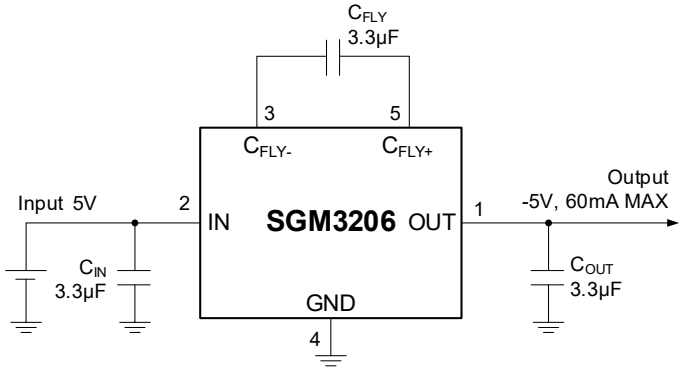


Figure 2. Typical Operating Circuit

REVISION HISTORY

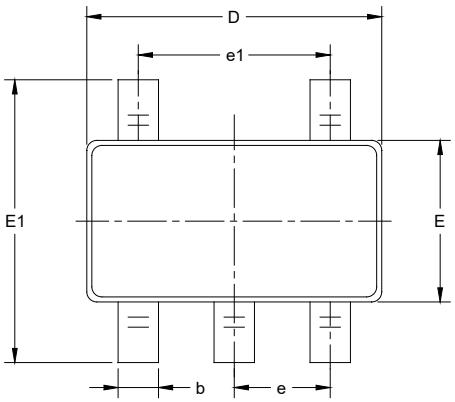
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

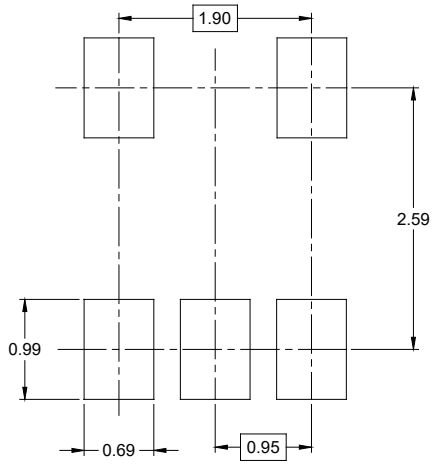
AUGUST 2024 – REV.A to REV.A.1	Page
Added SGM3206XN5G/TR (Operating Temperature Range: -40℃ to +125℃)	All
Added Package Thermal Resistance section	2
Updated Electrical Characteristics section	4
Updated Typical Performance Characteristics section	5

Changes from Original (JANUARY 2014) to REV.A	Page
Changed from product preview to production data	All

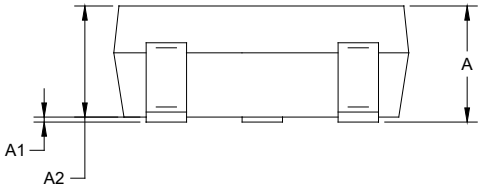
PACKAGE OUTLINE DIMENSIONS

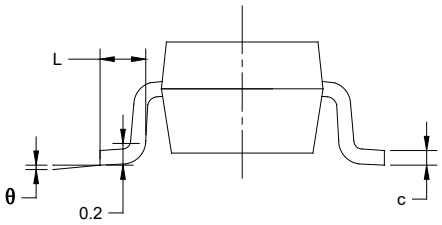
SOT-23-5





RECOMMENDED LAND PATTERN (Unit: mm)



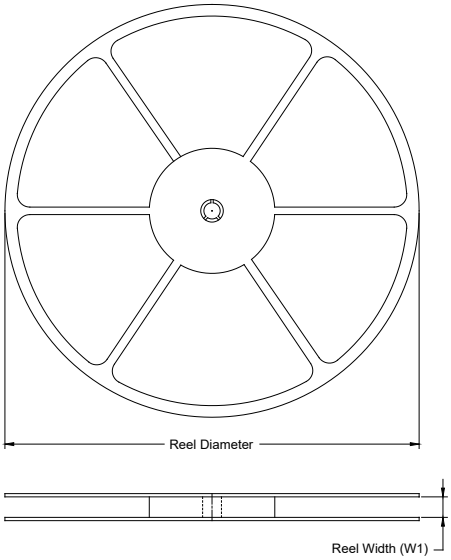


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

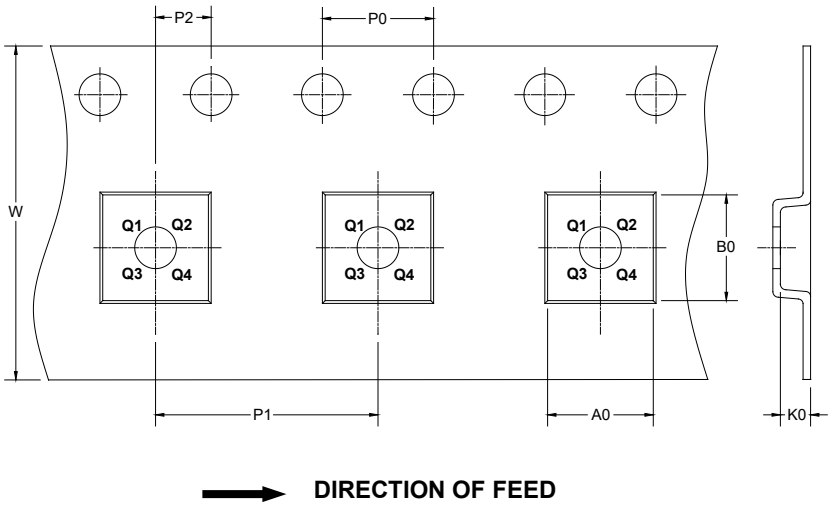
NOTES:
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

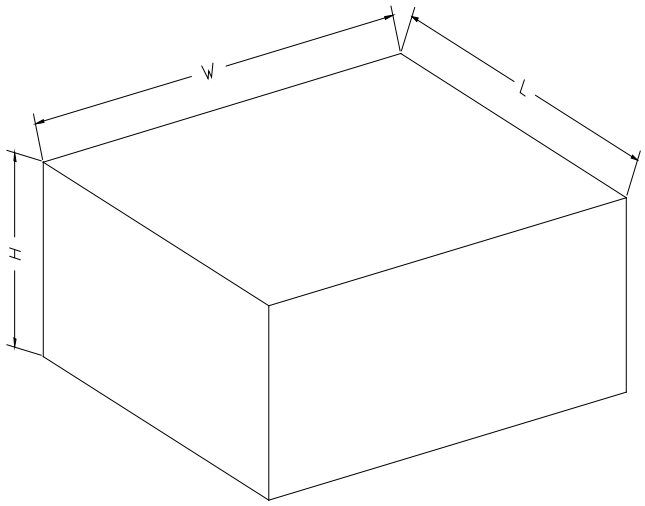
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-5	7″	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002