
Rail-to-Rail Analog Output Linear Hall Sensor

1. Features

- Rail-to-Rail analog output
- Low noise output
- Fast power-up time: < 5 μ s
- Operating voltage: 2.8V to 5.5V
- Quiescent output voltage: 50% of VCC
- High-speed 1MHz detection bandwidth
- Wide operating temperature range: -40°C to 125°C
- SOT23-3L PKG

2. Applications

- Magnetic shaft keyboards
- Joystick knobs
- Position detection
- Game controllers and peripherals

3. Description

The SC4009 is a high-performance, rail-to-rail analog output linear Hall sensor. The output voltage varies proportionally with the supply voltage, with a quiescent output voltage equal to half of the supply voltage. At 3.3V, the typical sensitivity is 2.1mV/Gs.

The SC4009 provides a low-noise output with temperature compensation. The sensor IC operates over a temperature range of -40°C to 125°C, making it suitable for both consumer and industrial environments.

The SC4009 has a wide supply voltage range, operating from 2.8V to 5.5V. The device is packaged in a lead-free, 100% matte tin frame plating.



Fig.1 SOT23-3L Package Outline

CONTENTS

1. Features.....	1	9. Operating Characteristics.....	6
2. Applications	1	9.1 Electrical Parameter	6
3. Description	1	9.2 Magnetic Parameter	6
4. Terminal Configuration	3	10. Block Diagram.....	7
5. Ordering Information.....	4	11. Function Description	7
6. Absolute Maximum Ratings	5	12. Typical Application	9
7. ESD Protection	5	13. Package Information “SOT23-3L(SO)”	10
8. Thermal characteristics	5	14. Revision History	11

4. Terminal Configuration

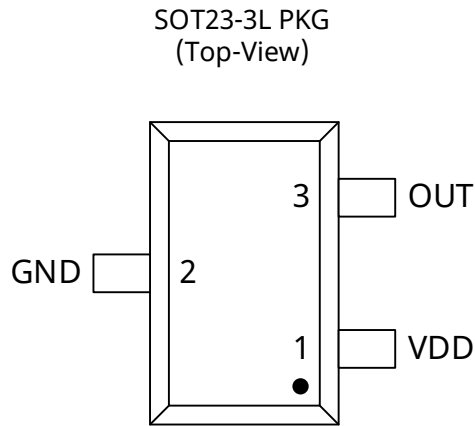


Fig.2 SOT23-3L Pin Description

Name	Description	
	SOT23-3L	
VCC	1	Power supply
GND	2	Ground
OUT	3	Output

5. Ordering Information

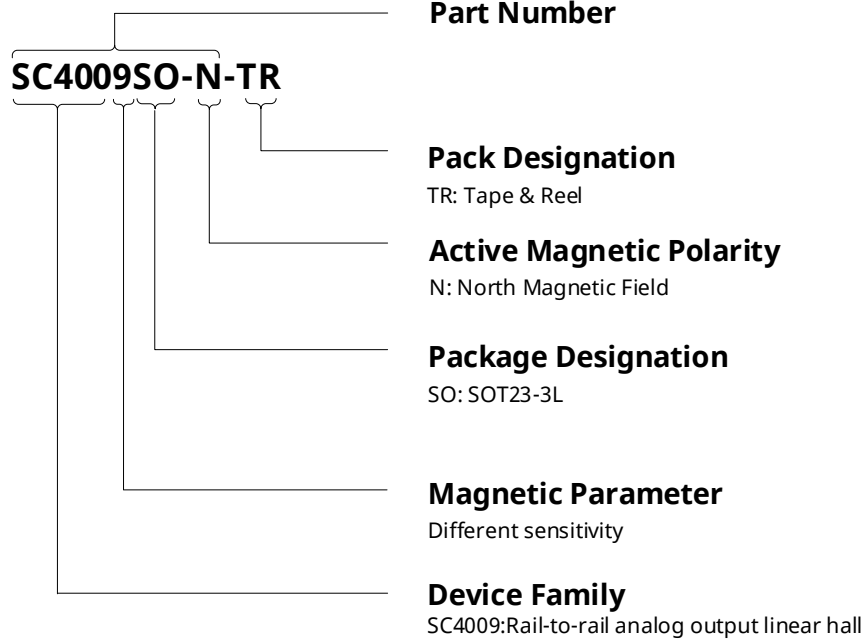
Ordering Information	Sens(mV/Gs) ⁽¹⁾	Ambient, T _A (°C)	Package	Packing	Quantity
SC4009SO-N-TR ⁽²⁾	2.1	-40~125	SOT23-3L	TR	3000

Note:

(1) This sensitivity data is available under 3.3v application conditions

(2) TR: Tape & Reel

Order information format description



6. Absolute Maximum Ratings

Symbol	Parameter	Notes	Min.	Max.	Units
$V_{CC\ abs}$	Positive Supply Voltage	$B=0mT, T_A=25^{\circ}C$	-	18	V
$V_{CCr\ abs}$	Negative Supply Voltage	$B=0mT, T_A=25^{\circ}C$	-0.3	-	V
$V_{OUT\ ABS}$	Positive Output Voltage	$B=0mT, T_A=25^{\circ}C$	-	18	V
$V_{OUTR\ ABS}$	Negative Output Voltage	$B=0mT, T_A=25^{\circ}C$	-0.3	-	V
T_A	Operating Temperature Range	-	-40	125	$^{\circ}C$
T_{STG}	Storage Temperature Range	-	-55	165	$^{\circ}C$
$T_{J(max)}$	Maximum Junction Temperature	-	-	165	$^{\circ}C$

Note:

Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

7. ESD Protection

Symbol	Parameter	Test conditions	Min.	Max.	Units
V_{ESD_HBM}	HBM	Refer to ANSI/ESDA/JEDEC JS-001 standard ⁽¹⁾	-4	+4	kV
V_{ESD_CDM}	CDM	Refer to ANSI/ESDA/JEDEC JS-002 standard ⁽²⁾	-750	+750	V

Note:

(1) JEDEC document JEP155 states that 4000V HBM allows safe manufacturing using standard ESD control processes.

(2) JEDEC document JEP157 states that 740V CDM allows safe manufacturing using standard ESD control processes.

8. Thermal characteristics

Symbol	Parameter	Test conditions	Value ⁽¹⁾	Units
$R_{\theta JA}$	SOT23-3L	Single-layer PCBS, JEDEC 2s2p and 1s0p are defined in JESD 51-7 and JESD 51-3	228	$^{\circ}C/W$

Note:

(1) The maximum operating voltage must meet the requirements of power consumption and junction temperature, refer to thermal characteristics

9. Operating Characteristics

9.1 Electrical Parameter

(TA=25°C, VDD=3.3V, unless otherwise noted)

Symbol	Parameter	Test Condition	Min	TYP	MAX	Unit
V _{CC}	Operating Voltage	-	2.8	3.3	5.5	V
I _{CC}	Operating Current	V _{CC} = 3.3V, B = 0Gs	-	2.2	3	mA
T _{PO}	Power-On Time	V _{CC} = 3.3V, B = 0Gs, V _{OUT} = 90% of Full-Scale	-	5	-	us
I _{SINK}	Output Sink Current	-	-1.5	-	-	mA
I _{SOURCE}	Output Source Current	-	-	-	1.5	mA
R _L	Output Load Resistance	OUT to GND	2	-	-	kΩ
C _{OUT}	Output Load Capacitance	-	-	-	1	nF
F _{BW}	Detection Bandwidth	(-3 dB)	1	-	-	MHz
T _{PD}	Response Delay Time	-	-	1	-	us

9.2 Magnetic Parameter

(TA=25°C, VDD=3.3V, unless otherwise noted)

Symbol	Parameter	Test Condition	Min	TYP	MAX	Unit
V _{QT}	Quiescent voltage	B = 0Gs, T _A = 25°C, V _{CC} = 3.3 V	-	1.65	-	V
V _{QΔT}	Quiescent voltage temperature drift	B = 0Gs, V _{CC} = 3.3 V, T _A = -40°C to 105°C versus 25°C	-	±1% ×V _{CC}	-	V
V _{QRE}	Quiescent voltage ratio error	-	-	±0.2	-	%
S	Sensitivity	V _{CC} = 3.3V, T _A = 25°C	-	2.1	-	mV/Gs
BL	Linear magnetic induction range	V _{CC} = 3.3V, T _A = 25°C	-	±738	-	Gs
V _L	Output voltage linear range	-	0.2	-	V _{CC} -0.2	V
S _{TC}	Temperature coefficient of sensitivity	T _A = -40°C to 105°C versus 25°C	0.04	0.12	0.2	%/°C
S _{LE}	Sensitivity linear error	-	-	±1	-	%
S _{SE}	Sensitivity symmetry error	-	-	±1	-	%
V _N	Output reference peak-to-peak noise	SC4009, BW=10kHz	-	2	-	mVpp

Note:

1Gs = 0.1mT

10. Block Diagram

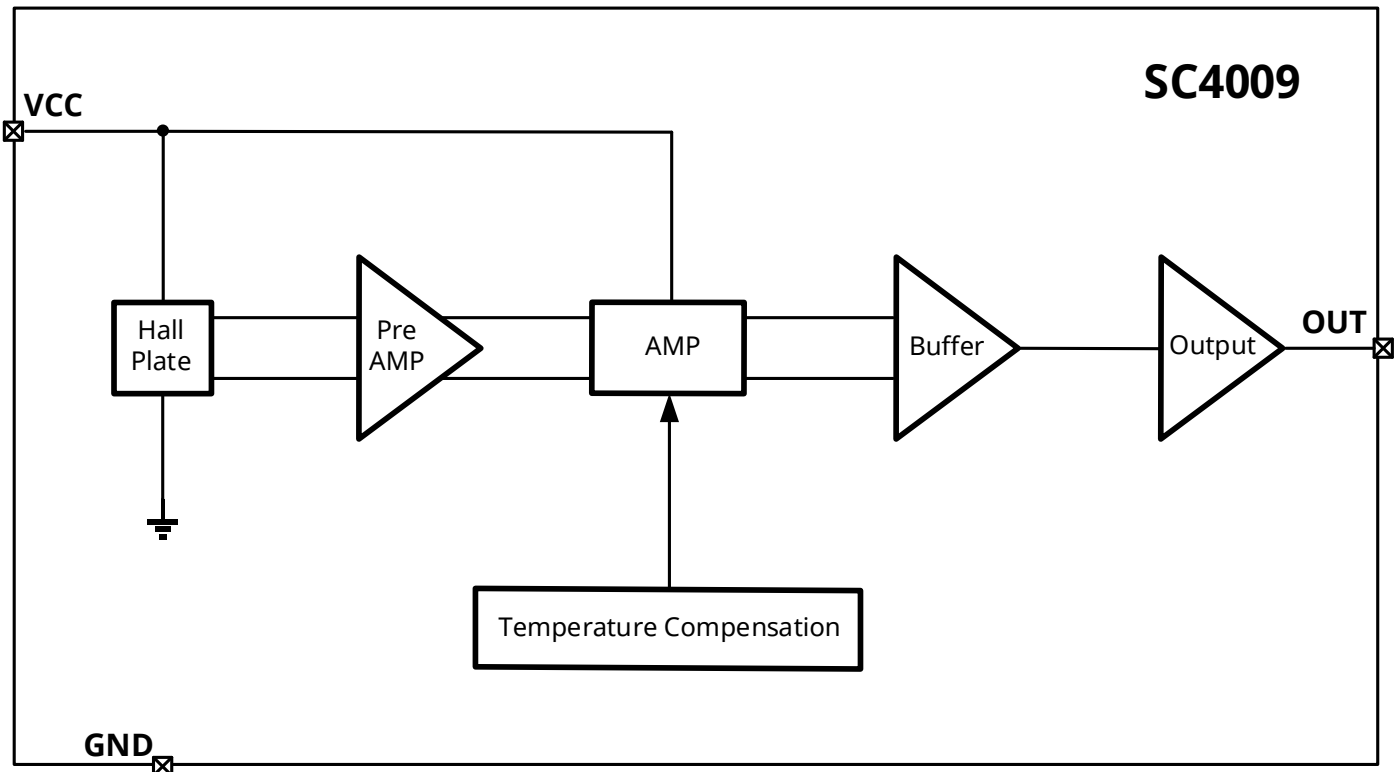


Fig.3 Block Diagram

11. Function Description

Magnetic Field Direction Definition: SOT23-3L(SO) package, the magnetic field S pole is defined as a negative magnetic field on the marking.

Quiescent Output Voltage (V_{OUTQ}): Quiescent Output Voltage indicates the output voltage of the IC when there is no magnetic field. Theoretically, the output voltage of SC4009 is equal to $VCC/2$, but due to the interference of bias voltage, sensitivity, packaging stress and other factors, the static output voltage does have a certain deviation from the theoretical value. The static output voltage is to some extent affected by the temperature coefficient, which statistically means that the static output voltage will also change with the change of temperature (the higher the sensitivity, the more obvious).

Sensitivity(S)

$$Sens = [VOUT(B1) - VOUT(B2)] / (B1 - B2)$$

When the South Pole magnetic field perpendicular to the chip tagged side approaches, the output voltage increases proportionally, until it reaches supply voltage. Conversely, when the North Pole magnetic field perpendicular to the chip tagged side approaches, the output voltage decreases proportionally, until it reaches ground level. Sensitivity is defined as the specific value of the output voltage variation and the magnetic field variation, commonly in mV/Gs or mV/mT.

Power-On Time (t_{PO}): Power-On Time (t_{PO}) is defined as the time it takes for the output voltage to settle within $\pm 10\%$ of its steady-state value under an applied magnetic field after the power supply has reached its minimum

specified operating voltage ($V_{CC(min)}$) as shown in Figure 4.

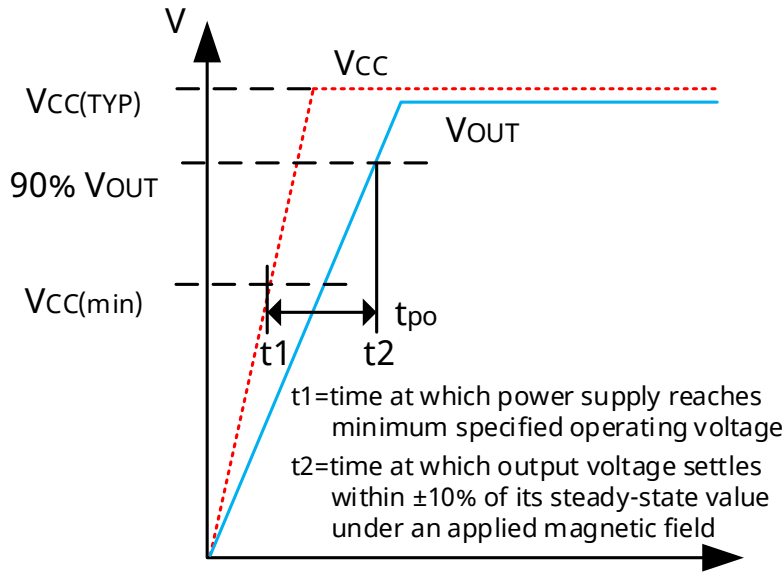


Fig.4 Power-On Time Definition

Propagation Delay (t_{PD}): The time interval between a) when the applied magnetic field reaches 20% of its final value, and b) when the output reaches 20% of its final value (see Figure 5).

Rise Time (t_r): The time interval between a) when the sensor IC reaches 10% of its final value, and b) when it reaches 90% of its final value (see Figure 5). t_r is detrimentally affected by eddy current losses observed in the conductive IC ground plane.

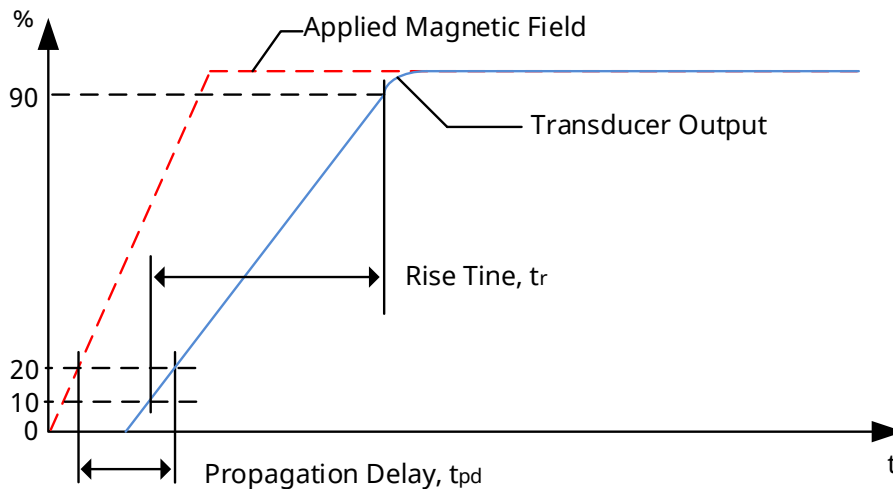


Fig.5 Propagation Delay and Rise Time Definitions

12. Typical Application

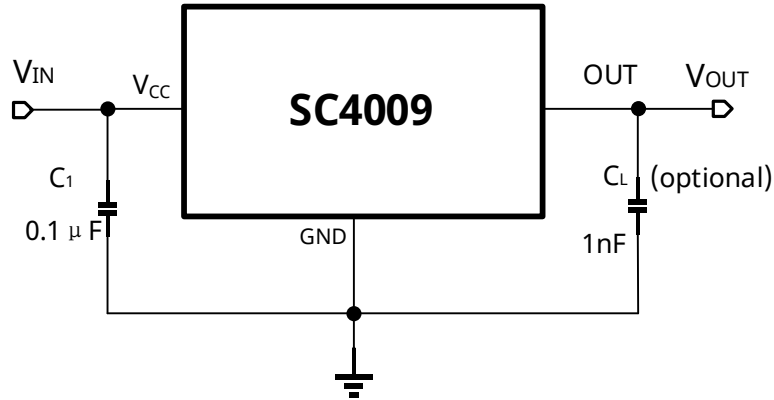


Fig.6 Typical Application Circuit

At rest (i.e. no significant magnetic field : $B=0$), the output $V_{OUT}(Q)$ is equal to $50\% \cdot V_{CC}$. The presence of a North Pole magnetic field perpendicular to the screen surface of the package increases the output voltage from its static value to the supply voltage rail, and the increase in output voltage is proportional to the applied magnetic field; Instead, applying a South Pole magnetic field will reduce the output voltage from its static value to the ground voltage rail, a ratio specified as the device's magnetic sensitivity $Sens$ (mV/Gs).

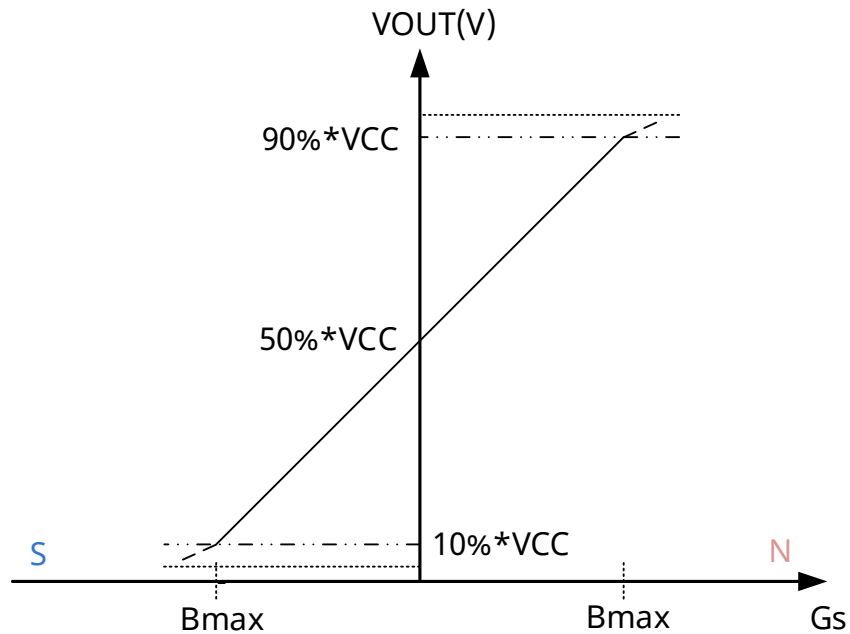
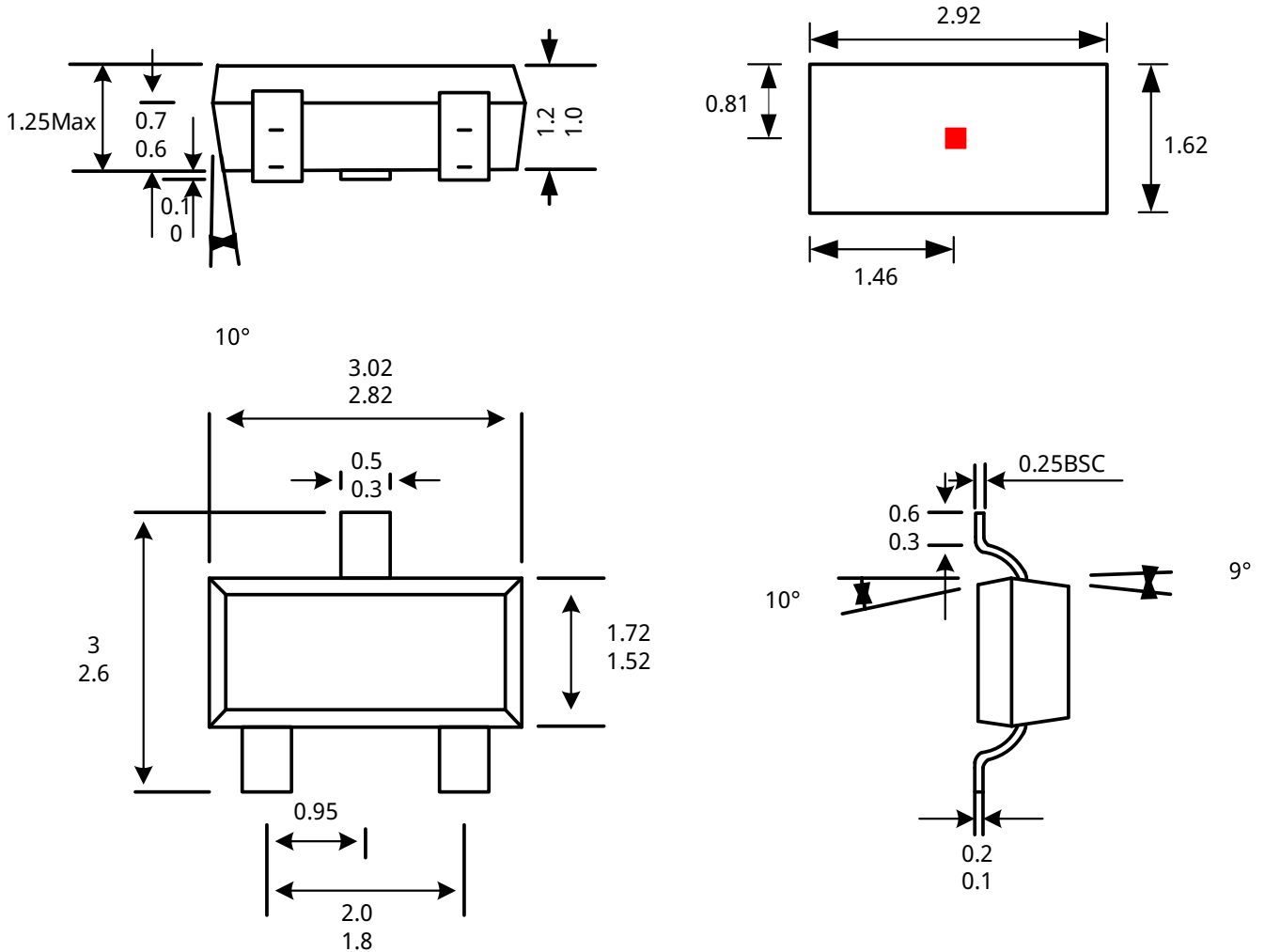


Fig.7 Output function

13. Package Information “SOT23-3L(SO)”

**3-PIN
SOT23-3L
Package**

Unit: mm



Notes:

1. Exact body and lead configuration at vendor’s option within limits shown.
2. Height does not include mold gate flash.

Where no tolerance is specified, dimension is nominal.

14. Revision History

Revision	Date	Description
Rev.0.1	2024-07-22	Preliminary datasheet
Rev.A1.0	2024-11-28	Unified datasheet format