NOVOSENSE
纳芯微电子

NST235

±1.5 °C High Precision Ultra-low Current Analog Temperature Sensor

Datasheet (EN) 1.2

Product Overview

The NST235 is a high precision CMOS analog output temperature sensor. The device offers a maximum accuracy of ±0.5°C at 25°C and a maximum of ±2.5°C over the full temperature range. The device is specified at the full temperature range of -40°C to 150°C and the power supply operating range is 2.3V to 5.5V.

The NST235 device provides a positive slope output of

10.0mV/°C over -40°C to 100°C. it is highly linear and does not require complex calculations or lookup tables to derive temperature.

The NST235 is a low power device, and the typical operating current is 20μA. Therefore, self-heating is negligible. The NST235 is available in SC70(5) and SOT-23(3) package, making it suitable for on-board and off-line applications in the industrial, and consumer markets applications in the IoT.

Key Features

- High Accuracy Over –40 °C to 150 °C Temperature Range
  - 0 °C ~ 70°C: ±0.5 °C (Typical)
  - 0 °C ~ 70°C: ±1.5 °C (Maximum)
  - -40 °C ~ 150°C: ±2.5 °C (Maximum)
- Operating Voltage Range: 2.3V to 5.5V
- Average Sensor Gain o: 10mV/°C
- Output Impedance: 1Ω (Typical)
- Operating Current: 20μA (Typical)
- Push-Pull Output Current Drain: 500μA (Maximum)
- Predictable Curvature Error
- Output Short Protection
- Suitable for Remote Applications
- Package: SOT-23(3) and SC70(5)

Applications

- Smartphones
- Portable Medical Instruments
- Notebook Computers
- Industrial Internet of Things (IoT)
- Power Supply Modules
- Power-system Monitors
- Thermal Protection
- Environmental Monitoring and HVAC
- Disk Drives

Device Information

Part Number	*Package*	*Body Size*
NST235	SC70(5)	2.00mm × 1.25mm
	SOT-23(3)	2.92mm × 1.30mm

Functional Block Diagrams

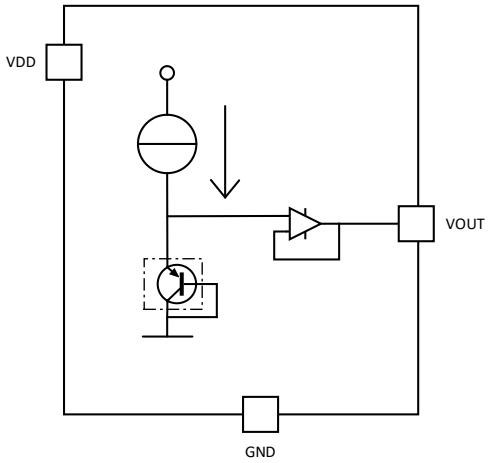


Figure 1 NST235 Functional Block Diagram

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1 Pin Configuration and Functions

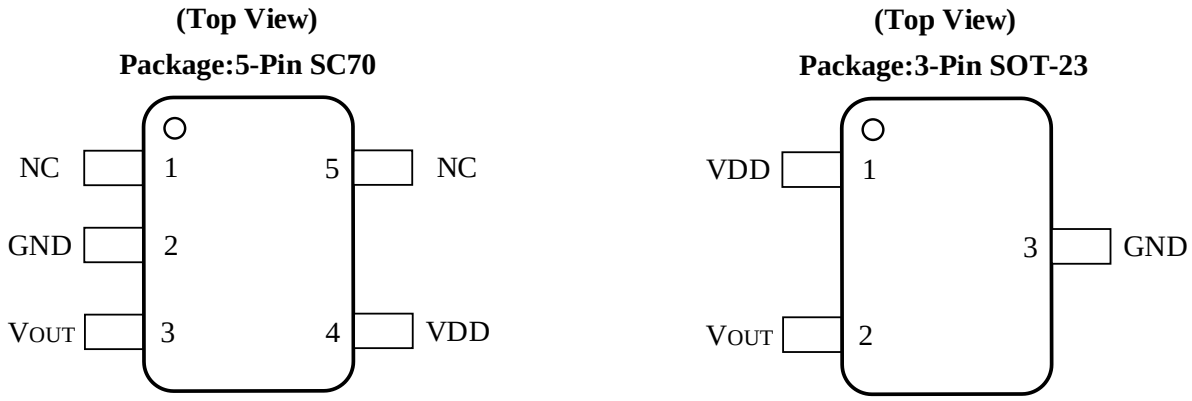


Figure 1.1 NST235 Pin Configuration

Table 1.1 NST235 Pin Function Description

Pinout			Type	Description
Name	SOT-23	SC70		
NC	-	1	-	No Connection
GND	3	2	GND	Ground pin, connect to power supply negative terminal. This pin must be grounded for optimum thermal conductivity.
V_{OUT}	2	3	Analog output	Analog voltage output
VDD	1	4	Power	Power supply input pin
NC	-	5	-	No Connection, must be floating or connect to grounded

2 Specifications

2.1 Absolute Maximum Ratings

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Supply Voltage Pin (VDD)	VDD	-0.3		6.5	V	
Output Volatge	Vout	-0.3		VDD+0.3	V	
Storage Temperature		-60		155	℃	
Operation Temperature	$TB_{operation}$	-40		150	℃	
Maximum Junction Temperature				155	℃	
ESD susceptibility	HBM	±4.5			KV	
	CDM	±500			V	

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2.2 Electrical Characteristics

at T_A = +25°C and VDD = +2.3V to +5.5 V, unless otherwise noted

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Supply						
Supply Voltage Range	VDD	2.3		5.5	V	
Supply Sensitivity			0.1		°C /V	
Operation Current	Iconv		20		μA	
Shutdown Current	I_{SD}		0.1		μA	VDD≤0.6V
Temperature Range						
Temperature Range		-40		150	°C	
Accuracy (Using equation 3-2)			±0.5	±1.5	°C	from 0°C to 70°C
			±0.5	±2.5	°C	from -40°C to 150°C
Output Voltage at 0°C			0.5		V	
Vout Drive Capability			500		μA	
Sensor Gain			10		mV/°C	
Output Impedance			1		Ω	
Load Regulation			0.5		mV	Source ≤50uA
Temperature Coefficient of Quiescent Current			-44		nA/°C	
Thermal response						
Stirred Oil Thermal Response Time to 63% of Final Value (Package Only)			0.418		s	
Drift						
Drift[1]			±0.2		°C	

Notes: 1. Drift data is based on a 1000-hour stress test at +130°C with VDD = 5.5V.

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2.3 Typical Characteristics

at VDD = 3.3 V, unless otherwise noted.

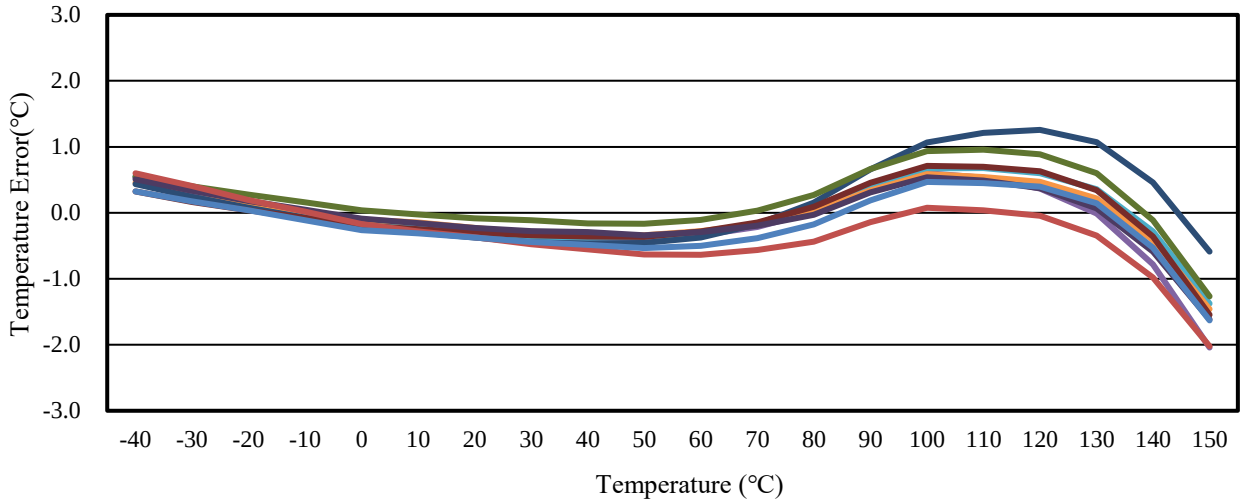


Figure 2.1 Temperature Error vs Temperature

3 Function Description

3.1 Overview

The NST235 is a high precision CMOS analog output temperature sensor. The device offers a maximum accuracy of ± 0.5°C at 25°C and a maximum of ±2.5°C over the full temperature range. The device is specified at the full temperature range of -40°C to 150°C and the power supply operating range is 2.3V to 5.5V.

The NST235 device provides a positive slope output of 10.0mV/°C over -40°C to 100°C. it is highly linear and does not require complex calculations or lookup tables to derive temperature.

The NST235 is a low power device, and the typical operating current is 20μA. Therefore, self-heating is negligible. The NST235 is available in SC70(5) and SOT-23(3) package, making it suitable for on-board and off-line applications in the industrial, and consumer markets applications in the IoT.

3.2 Functional Block Diagram

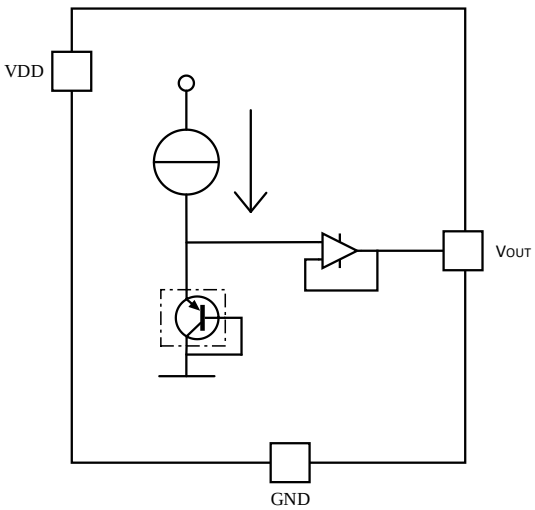


Figure 3.1 NST235 Functional Block Diagram

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3.3 Feature Description

3.3.1 NST235 Transfer Function

The NST235 device is linear. However, the output voltage will shift a little when the temperature is greater than 100°C. In order to achieve the highest accuracy performence of the device, we use piecewise linear function to describe the conversion relationship between temperature and output voltage. In the whole working temperature range, the conversion relationship of NST235 is shown in Table 3.2. The parameters of the piecewise linear function used in the three temperature ranges are shown in Table 3.1, and the output voltage is calculated by Equation 3-1:

$$V_O = T_C \times (T_A - T_I) + V_{OF} \quad (3\text{-}1)$$

Where, V_O is the output voltage at a given temperature.

T_A is the ambient temperature in °C.

T_I is the temperature inflection point for a piecewise segment in °C.

T_C is the temperature coefficient or gain of NST235.

V_{OF} is the voltage offset of NST235.

Therefore, in a certain output voltage range (V_R), given the output voltage value, the corresponding T_A can be calculated using Equation 3-2. For accuracy insensitive applications, the parameters in the first row of Table 3.1 can be used directly.

$$T_A = \frac{(V_O - V_{OF})}{T_C} + T_I \quad (3\text{-}2)$$

Table 3.1 NST235 Piecewise Linear Function Summary

T_A (°C)	V_R (mV)	T_I (°C)	T_C (mV/°C)	V_{OF} (mV)
–40 to 100	< 1500	0	10	500
100 to 125	1500 to 1752.5	100	10.1	1500
125 to 150	> 1752.5	125	10.6	1752.5

Table 3.2 NST235 Transfer Table

TEMPERATURE (°C)	VOUT (mV) IDEAL LINEAR VALUES	VOUT (mV) PIECEWISE LINEAR VALUES
–40	100	100
–35	150	150
–30	200	200
–25	250	250
–20	300	300
–15	350	350
–10	400	400
–5	450	450
0	500	500
5	550	550
10	600	600
15	650	650
20	700	700

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Table 3.2 NST235 Transfer Table(Continued)

TEMPERATURE (°C)	VOUT (mV) IDEAL LINEAR VALUES	VOUT (mV) PIECEWISE LINEAR VALUES
25	750	750
30	800	800
35	850	850
40	900	900
45	950	950
50	1000	1000
55	1050	1050
60	1100	1100
65	1150	1150
70	1200	1200
75	1250	1250
80	1300	1300
85	1350	1350
90	1400	1400
95	1450	1450
100	1500	1500
105	1550	1550.5
110	1600	1601
115	1650	1651.5
120	1700	1702
125	1750	1752.5
130	1800	1805.5
135	1850	1858.5
140	1900	1911.5
145	1950	1964.5
150	2000	2017.5

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3.3.2 Application Curve

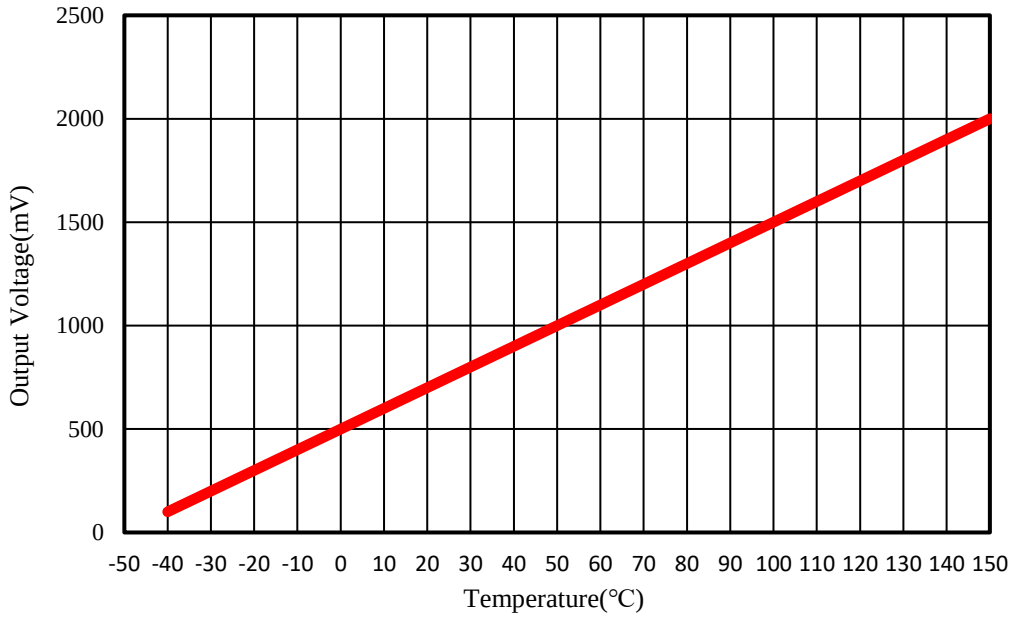


Figure 3.2 Output Voltage vs Temperature

4 Application Information

4.1 Capacitive Loads

As shown in the structure diagram, the output stage of NST235 is an amplifier. Generally, the output of the amplifier directly connected to the capacitive load is unstable. However, NST235 uses a special design, which makes it have 1000pF capacitive load capacity as shown in the Figure 4.1. If a larger capacitor is connected to filter the noise, an isolation resistance should be added between the output of NST235 and the capacitor as shown in the Table 4.1.

When the equipment is in an extremely noisy environment, it may be necessary to add an RC low-pass filter network to the output of NST235, such as a 1μF capacitor and a 800Ω series resistor. This low-pass filter will improve the thermal response time of NST235 and has the function of filtering high-frequency noise as shown in the Figure 4.2.

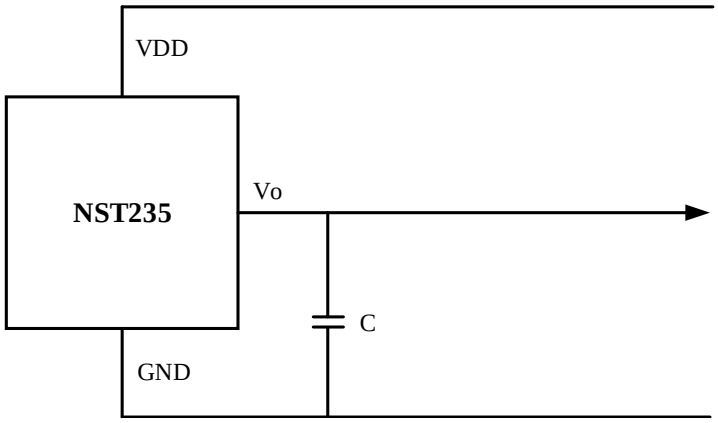


Figure 4.1 NST235 No Decoupling Required for Capacitive Loads Less Than 1000pF

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Table 4.1 Capacitive Loading Isolation

C (μF)	Minimum R(Ω)
1	800
0.1 to 0.999	1500
0.01 to 0.099	3000

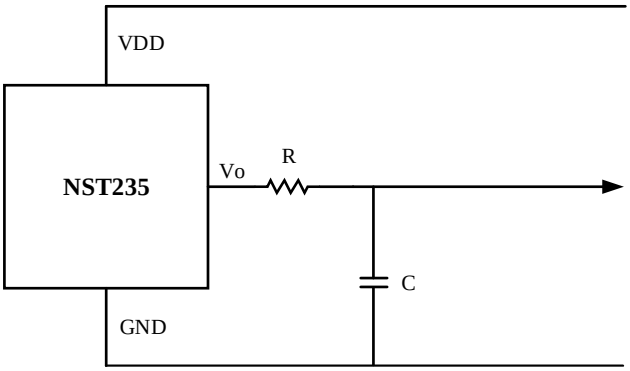


Figure 4.2 NST235 with RC Filter

4.2 Typical Application

As shown in Figure 4.3, the NST235 has an extremely low supply current and a wide supply range, therefore, it can be easily driven by a battery. In order to reduce the noise in the output voltage, it is recommended to add a 0.1μF capacitor between the power and the ground.

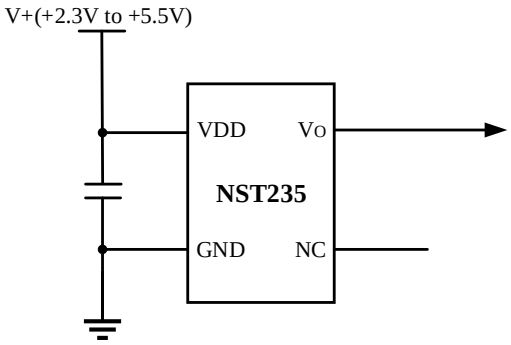


Figure 4.3 Typical Connections of the NST235

4.3 System Examples

4.3.1 Conserving Power Dissipation with Shutdown

Although NST235 has extremely low power consumption, for power-sensitive applications it can simply be shutdown by driving its supply pin with the output of a logic gate as shown in Figure 4.4.

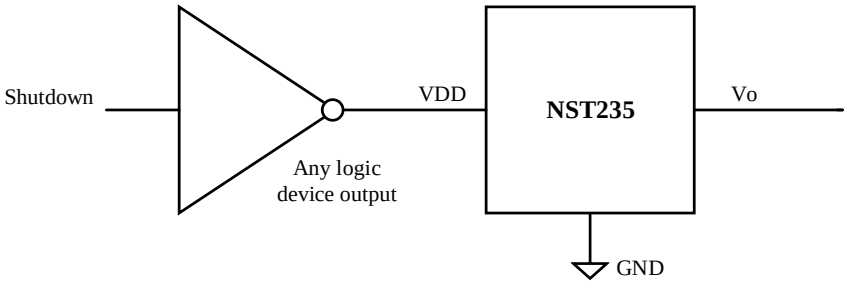


Figure 4.4 Conserving Power Dissipation with Shutdown

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4.3.2 Analog-to-Digital Converter Input Stage

The input structure of most CMOS ADCs is sample and hold structure. When ADC charges the sampling capacitor, it needs to draw instantaneous current from the signal source (such as NST235 temperature sensor and many operational amplifiers). By adding RC filter to the output stage of NST235, this requirement can be met. At this time, the instantaneous current is provided by the output capacitor. This ADC is shown as an example only, in Figure 4.5.

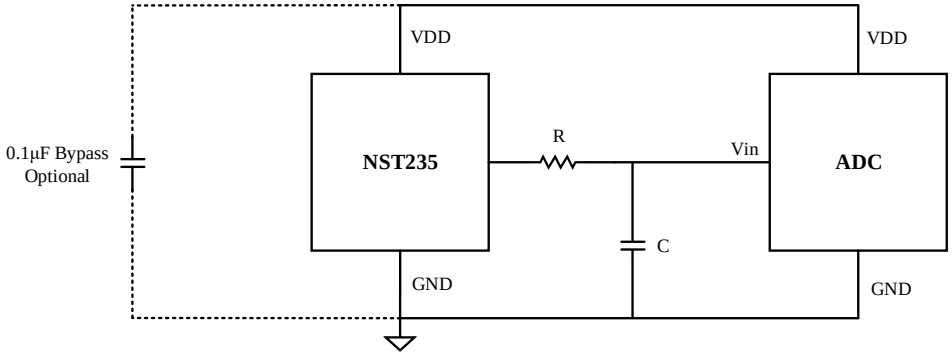


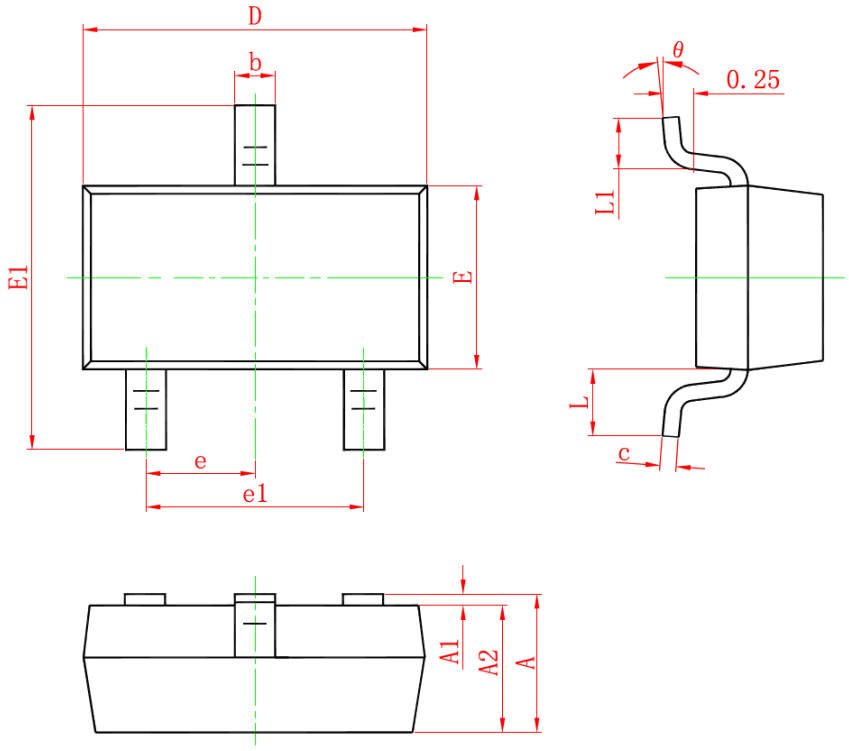
Figure 4.5 Suggested Connection to a Sampling Analog to Digital Converter Input Stage

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5 PACKAGE INFORMATION

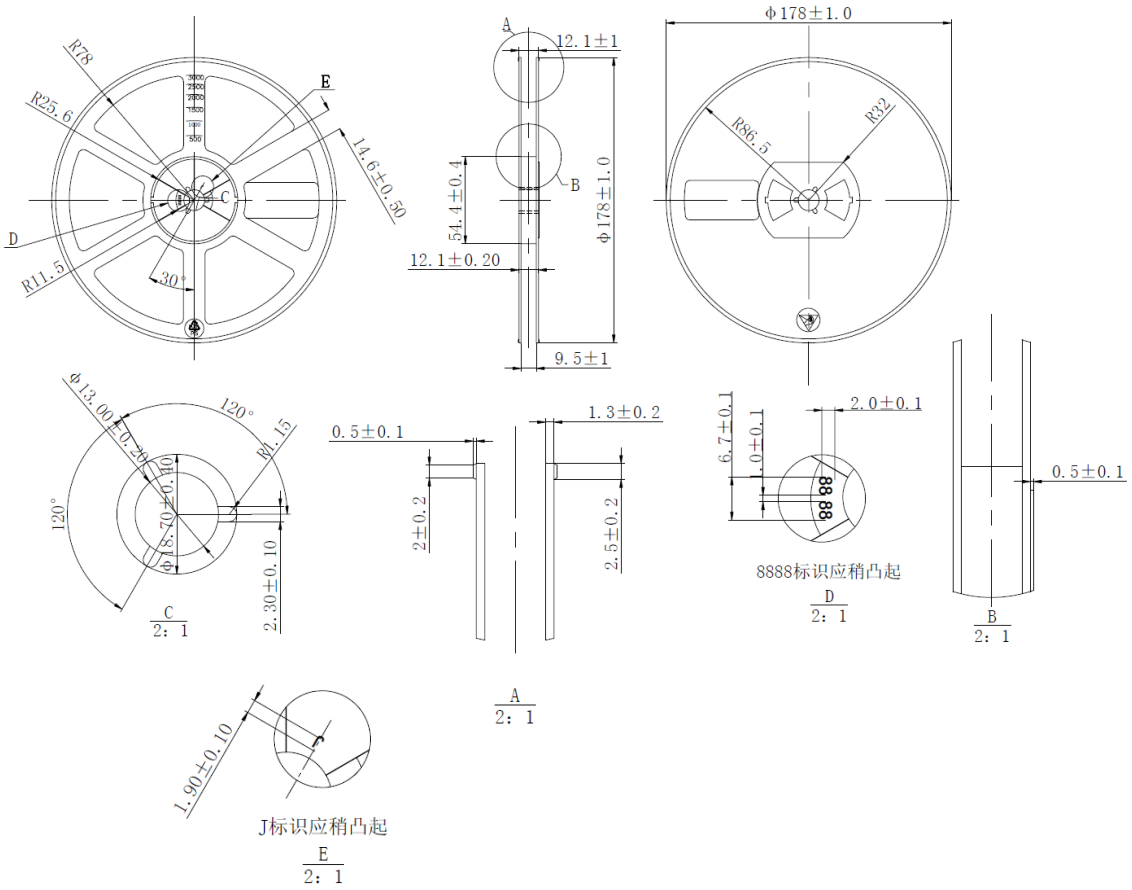
5.1 SOT-23(3) Package

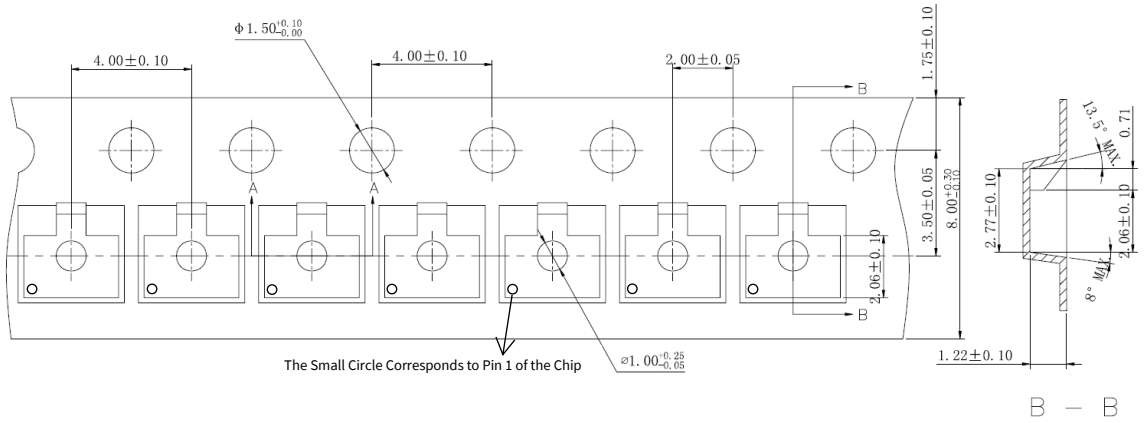


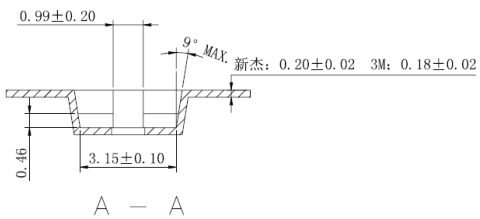
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.900	1.150	0.035	0.045
A1	0.000	0.100	0.000	0.004
A2	0.900	1.050	0.035	0.041
b	0.300	0.500	0.012	0.020
c	0.080	0.150	0.003	0.006
D	2.800	3.000	0.110	0.118
E	1.200	1.400	0.047	0.055
E1	2.250	2.550	0.089	0.100
e	0.950 TYP.		0.037 TYP.	
e1	1.800	2.000	0.071	0.079
L	0.550REF.		0.022REF.	
L1	0.300	0.500	0.012	0.020
θ	0°	8°	0°	8°

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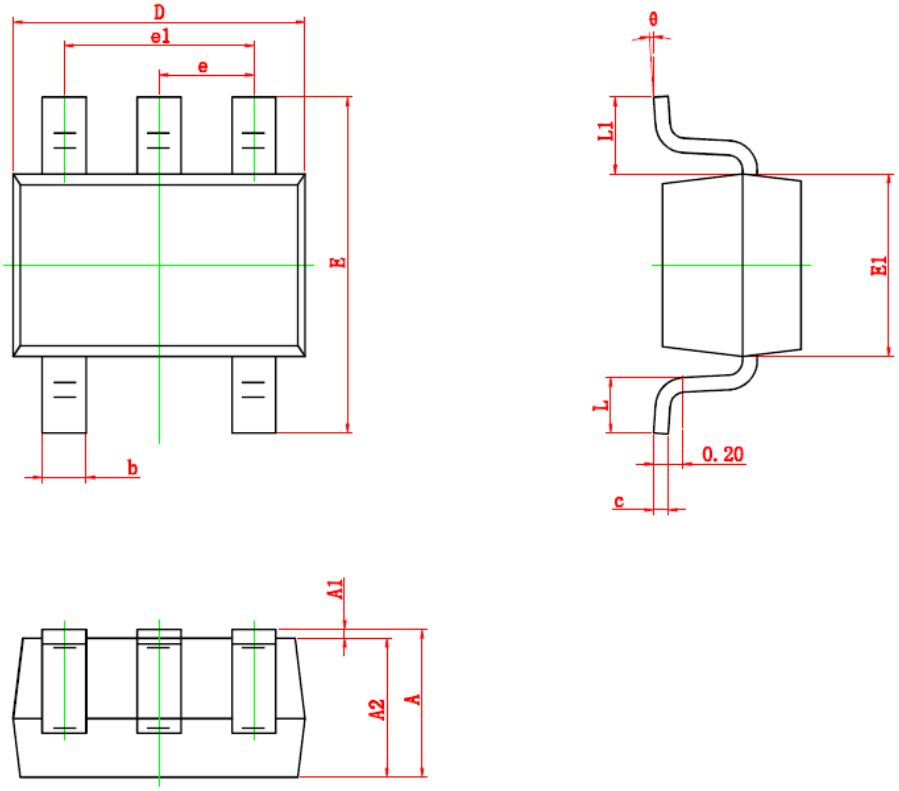


Tape and Reel Information of SOT-23(3)

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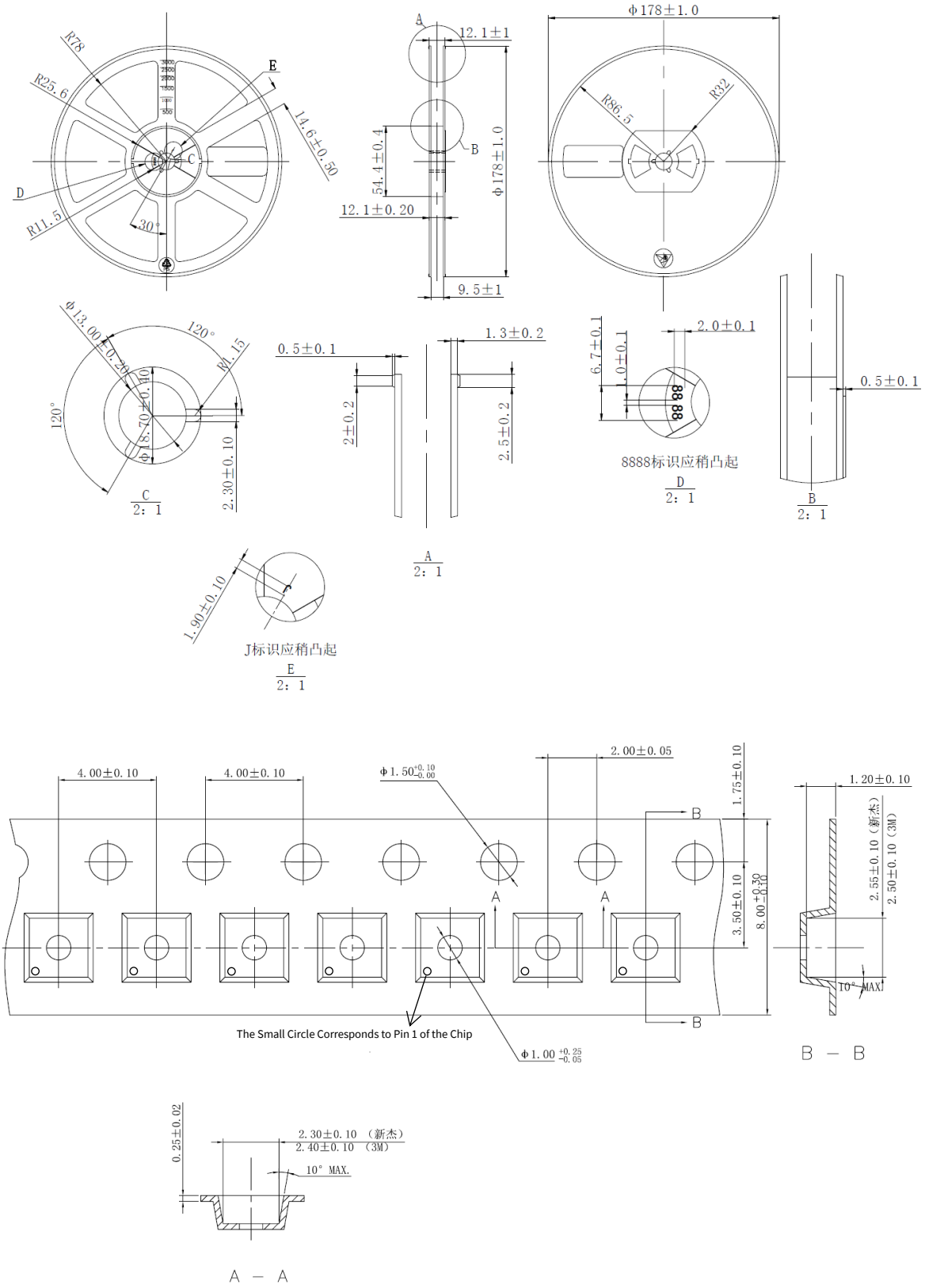
5.2 SC70(5) Package



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.110	0.175	0.004	0.007
D	2.000	2.200	0.079	0.087
E	2.150	2.450	0.085	0.096
E1	1.150	1.350	0.045	0.053
e	0.650 TYP.		0.026 TYP.	
e1	1.200	1.400	0.047	0.055
L	0.260	0.460	0.010	0.018
L1	0.525 REF.		0.021 REF.	
θ	0°	8°	0°	8°

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Tape and Reel Information of SC70(5)

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6 Order Information

Type	*Unit*	*MSL*	*Marking*	*Description*
NST235-DSTR	3000ea/Reel	1	235XXX	SOT-23(3) package, Reel
NST235-DSCR	3000ea/Reel	1	23XX	SC70(5) package, Reel
NOTE: All packages are RoHS-compliant with peak reflow temperatures of 260 °C according to the JEDEC industry standard classifications and peak solder temperatures (Reflow profile: J-STD-020E).				

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7 Revision History

Revision	*Description*	*Date*
1.0	Initial Version	2020/11/28
1.1	Revise information. Optimize text presentation	2022/03/30
1.2	Update Functional Description. Update Pin Configuration Diagram. Update Load Regulation of Electrical Characteristics.Revise Application Information. Optimize Text Presentation.Tape and reel show 1 pin.	2022/08/04

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