NST235

± 1.5 °C high precision ultra-low current analog temperature sensor

Datasheet (EN) 1.1

Product Overview

The NST235 is a precision analog output CMOS integrated-circuit temperature sensor that operates over -40°C to 150°C. The power supply operating range is 2.3V to 5.5V. The transfer function of NST235 is predominately linear, yet has a slight predictable parabolic curvature. The maximum temperature accuracy of the NST235 is ± 1.5°C at an ambient temperature of 25°C. The temperature error increases linearly and reaches a maximum of ±2.5°C at the temperature range extremes. The temperature range is affected by the power supply voltage. The NST235 device provides a positive slope output of 10mV/°C over the full –40°C to +150°C temperature range and a supply range from 2.3V to 5.5V. The NST235 quiescent typical current is 20µA. Therefore, self-heating is negligible. The devices can replace industrystandard parts directly like TMP235.

Key Features

- High Accuracy Over –40 °C to 150 °C Wide 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)
- Average Sensor Gain of 10mV/°C
- Predictable Curvature Error
- Operating voltage range: 2.3V to 5.5V
- Output short protection
- Push-Pull Output With ±500µA Drive Capability
- Operating current: 20µA(Typical)
- Suitable for Remote Applications
- Package
  - SOT-23 (3)
  - SC70 (5)

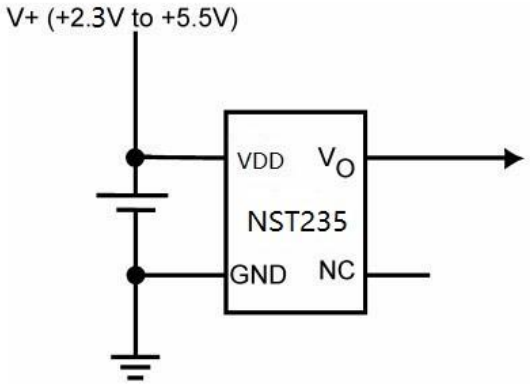
Applications

- 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

Typical Application



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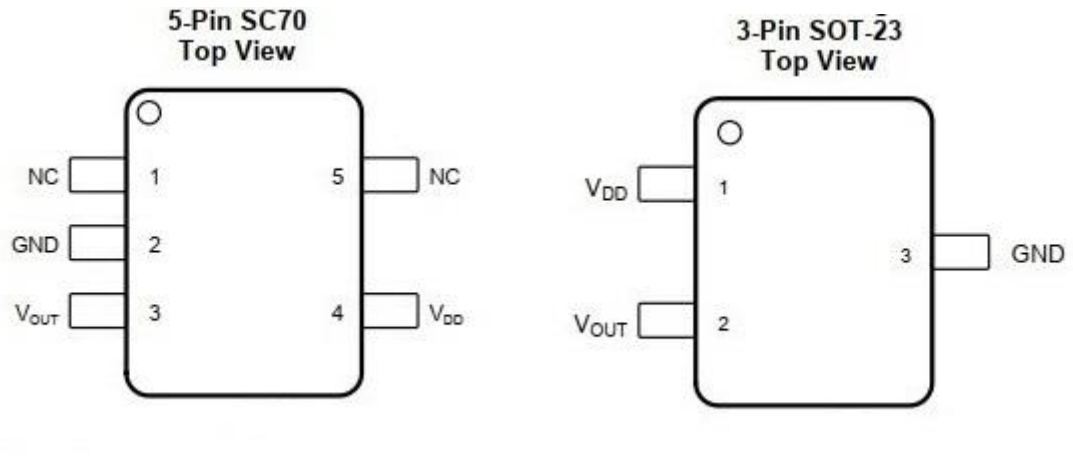
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PIN CONFIGURATION AND FUNCTIONS



SC70 (5) function **SOT-23 (3) function**

Pinout			Type	Description
Name	SOT-23	SC70		
NC	-	1	-	NC (pin 1) must be left floating or grounded. Other signal traces must not be connected to this pin
GND	3	2	GND	Device substrate and die attach paddle, connect to power supply negative terminal. For optimum thermal conductivity to the PC board ground plane, pin 2 must be grounded. This pin may also be left floating.
V_{OUT}	2	3	Analog output	Temperature sensor analog output
V_{DD}	1	4	Power	Positive power supply pin
GND	-	5	GND	Device ground pin, connect to power supply negative terminal.

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1.0 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	°C	
Operation temperature	$TB_{operation}$	-40		150	°C	
Maximum junction temperature				155	°C	
ESD susceptibility	HBM	±4.5			KV	
	CDM	±500			V	

2.0 ELECTRICAL CHARACTERISTICS

2.1 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	3.3	5.5	V	
Supply sensitivity			0.1		°C /V	
Operation current	Iconv		17		μA	
Shutdown current	I_{SD}		0.1		μA	VDD≤0.6V
Temperature Range						
Temperature Range		-40		150	°C	
Accuracy (Using equation 3-2)		-1.5	± 0.5	1.5	°C	From -0℃ to 70℃
		-2.5		2.5	°C	From -40℃ to 150℃
Output Voltage at 0°C			0.5		V	
Vout drive capability			500		μA	
Sensor Gain			10		mV/°C	
Output Impedance			1		Ω	
Load Regulation			0.05		mV	Source ≤50uA

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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)			TBD		°C	

Notes： (1) Drift data is based on a 1000-hour stress test at +125°C with VDD = 5.5V.

2.2 Typical Characteristics

At VDD = 3.3 V, unless otherwise noted.

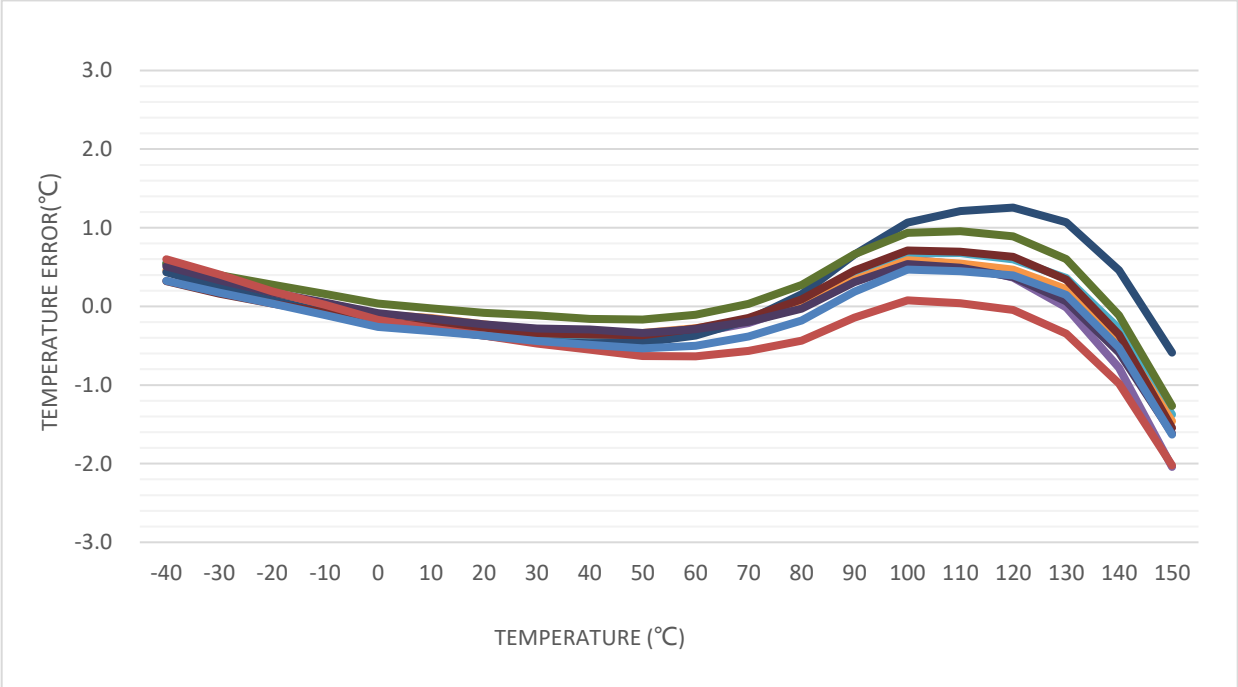


Figure 2.1 Using SC70(5) test, VDD= 3.3V

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3.0 FUNCTION DESCRIPTION

3.1 Function description

The NST235 device is a precision analog output CMOS integrated-circuit temperature sensor that operates over a temperature range of -40°C to 150°C. The power supply operating range is 2.3V to 5.5V. The transfer function of NST235 is predominately linear, yet has a slight predictable parabolic curvature. The accuracy of the NST235 when specified to a parabolic transfer function is typically ±0.5°C at an ambient temperature of 25°C. The temperature error increases linearly and reaches a maximum of ±2.5°C at the temperature range extremes for the NST235. The temperature range is affected by the power supply voltage. At a power supply voltage of 2.3V to 5.5V, the temperature range extremes are 150°C and -40°C. The NST235 typical quiescent current is 20 µA. Therefore, self-heating is negligible. Shutdown capability for the NST235 is intrinsic because its inherent low power consumption allows it to be powered directly from the output of many logic gates or, does not necessitate shutdown at all. The temperature sensing element is comprised of a simple base emitter junction that is forward biased by a current source. The temperature sensing element is then buffered by an amplifier and provided to the out pin. The amplifier has a simple class AB output stage thus providing a low impedance output that can source 500µA and sink 500µA.

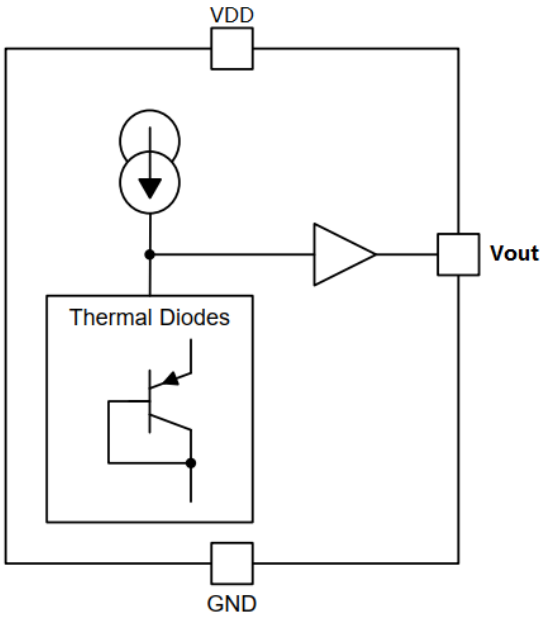


Figure 3.1 NST235 Functional Block Diagram

3.2 Feature Description

3.2.1 NST235 Transfer Function

As shown in Figure 3.2, the NST235 devices are linear. A small V_{OUT} gain shift, however, is present at temperatures above 100°C. When small shifts are expected, a piecewise linear function provides the best accuracy and is used for the device accuracy specifications. Typical output voltages of the NST235 devices across the full operating temperature range are listed in Table 3.2. The ideal linear columns represent the ideal linear V_{OUT} output response with respect to temperature, while the piecewise linear columns indicate the small voltage shift at elevated temperatures.

The piecewise linear function uses three temperature ranges listed in Table 3.1. In equation form, the voltage output V_{OUT} of the NST235 is calculated by Equation 3-1:

$$V_{OUT} = (T_A - T_{INFL}) \times T_C + V_{OFFS} \quad (3\text{-}1)$$

Where

• V_{OUT} is the NST235 voltage output for a given temperature

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- T_A is the ambient temperature in °C
- T_{INFL} is the temperature inflection point for a piecewise segment in °C
- T_C is the NST235 temperature coefficient or gain
- V_{OFFS} is the NST235 voltage offset

Therefore, the T_A temperature for a given V_{OUT} voltage output within a piecewise voltage range (VRANGE) is calculated in Equation 3-2. For applications where the accuracy enhancement above 100°C is not required, use the first row of Table 3-1.

$$T_A = (V_{OUT} - V_{OFFS})/T_C + T_{INFL} \quad (3\text{-}2)$$

Table 3.1 NST235 Piecewise Linear Function Summary

T_A RANGE (°C)	V_{RANGE} (mV)	T_{INFL} (°C)	T_C (mV/°C)	V_{OFFS} (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)	V_{OUT} (mV) IDEAL LINEAR VALUES	V_{OUT} (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
25	750	750
30	800	800
35	850	850
40	900	900

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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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3.2.2 Application Curve

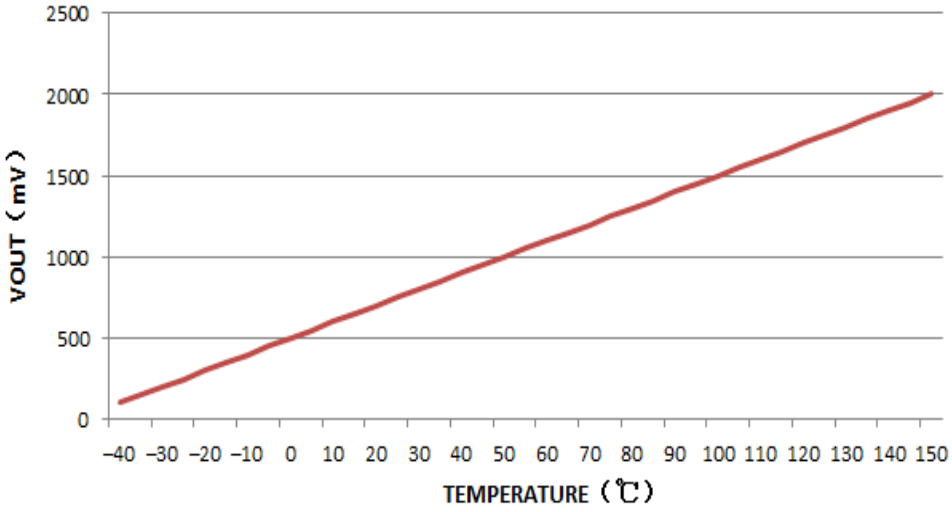


Figure 3.2 Output Voltage vs Temperature

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4.0 TYPICAL APPLICATION

4.1 CAPACITIVE LOADS

The NST235 will handle capacitive loads of up to 1000 pF. Over the specified temperature range, the NST235 has an output impedance of 1Ω. In a noisy environment; it may be advisable to add some filtering to minimize noise in the output voltage. A 0.1 µF capacitor added between the supply voltage and ground is recommended. In an extremely noisy environment, it may be necessary to add a low-pass filter network to the output of the device. A 1 µF capacitor, in addition to the output impedance of the device, and an 800 Ω series resistor, will provide a low-pass filter that will pass the slow thermal time constant of the NST235, while filtering the higher frequency noise.

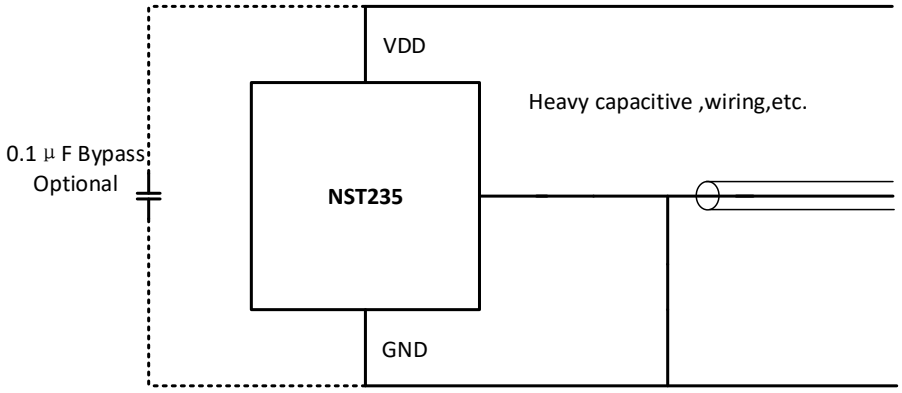


Fig 4.1 NST235 No Decoupling Required for Capacitive Loads Less Than 1000 pF

Capacitive Loading Isolation

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

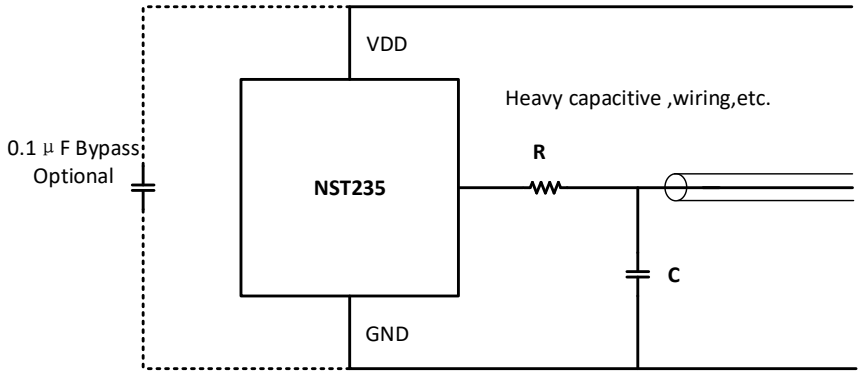


Fig 4.2 NST235 With Compensation for Capacitive Loading Greater Than 300 pF

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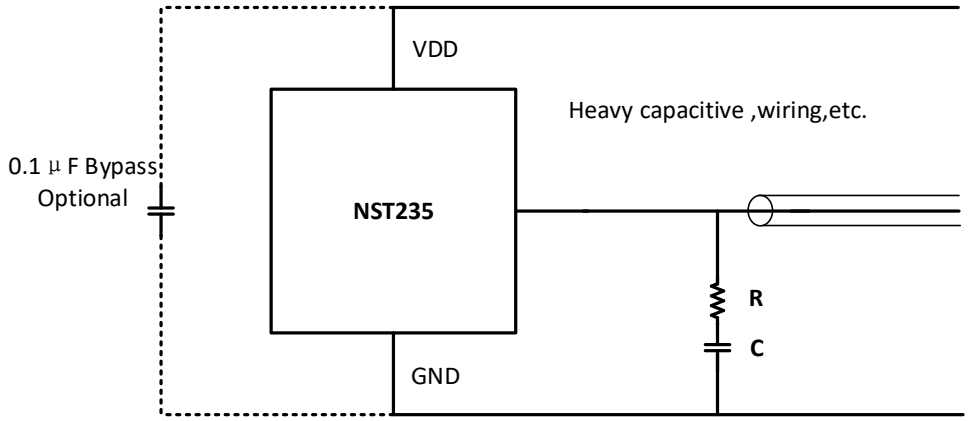


Fig 4.3 NST235 With Compensation for Capacitive Loading Greater Than 300 pF

4.2 TYPICAL APPLICATION

The NST235 has a very low supply current and a wide supply range; therefore, it can easily be driven by a battery as shown in Figure 4.4.

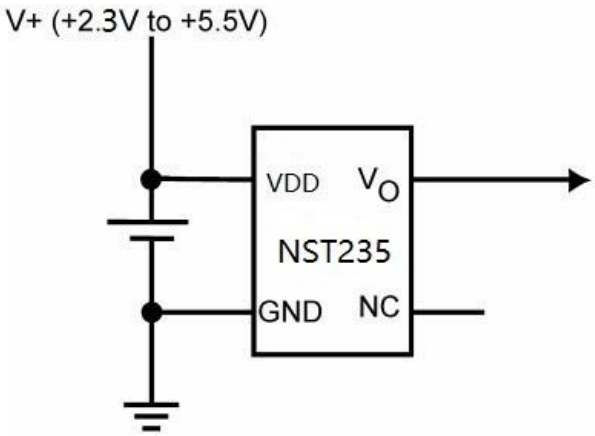


Figure 4.4. Typical Connections of the NST235

4.3 SYSTEM EXAMPLES

4.3.1 Conserving Power Dissipation with Shutdown

The NST235 draws very little power; therefore, it can simply be shutdown by driving its supply pin with the output of a logic gate as shown in Figure 4.5.

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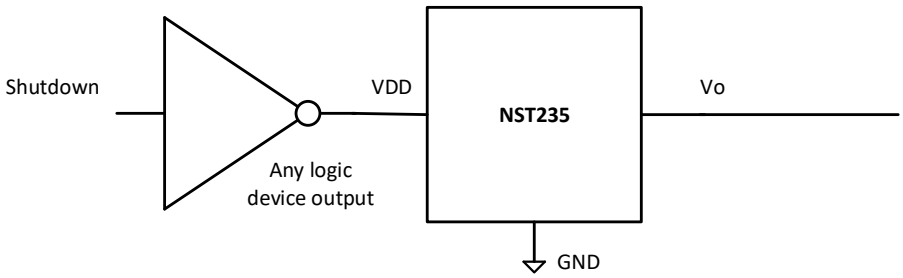


Figure 4.5 Conserving Power Dissipation with Shutdown

4.3.2 Analog-to-Digital Converter Input Stage

Most CMOS ADCs found in ASICs have a sampled data comparator input structure that is notorious for causing grief to analog output devices such as the NST235 and many operational amplifiers. The cause of this grief is the requirement of instantaneous charge of the input sampling capacitor in the ADC. This requirement is easily accommodated by the addition of a capacitor. Because not all ADCs like Figure 4.6 have identical input stages, the charge requirements will vary necessitating a different value of compensating capacitor. This ADC is shown as an example only.

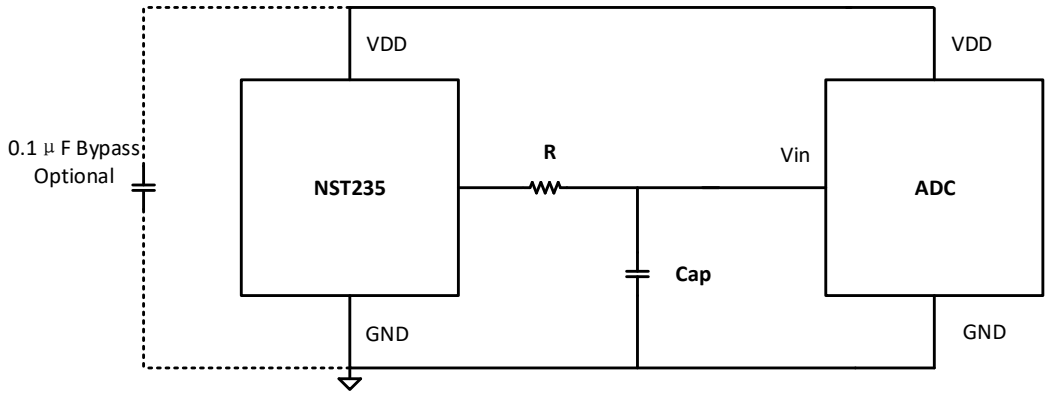


Figure 4.6 Suggested Connection to a Sampling Analog to Digital Converter Input Stage

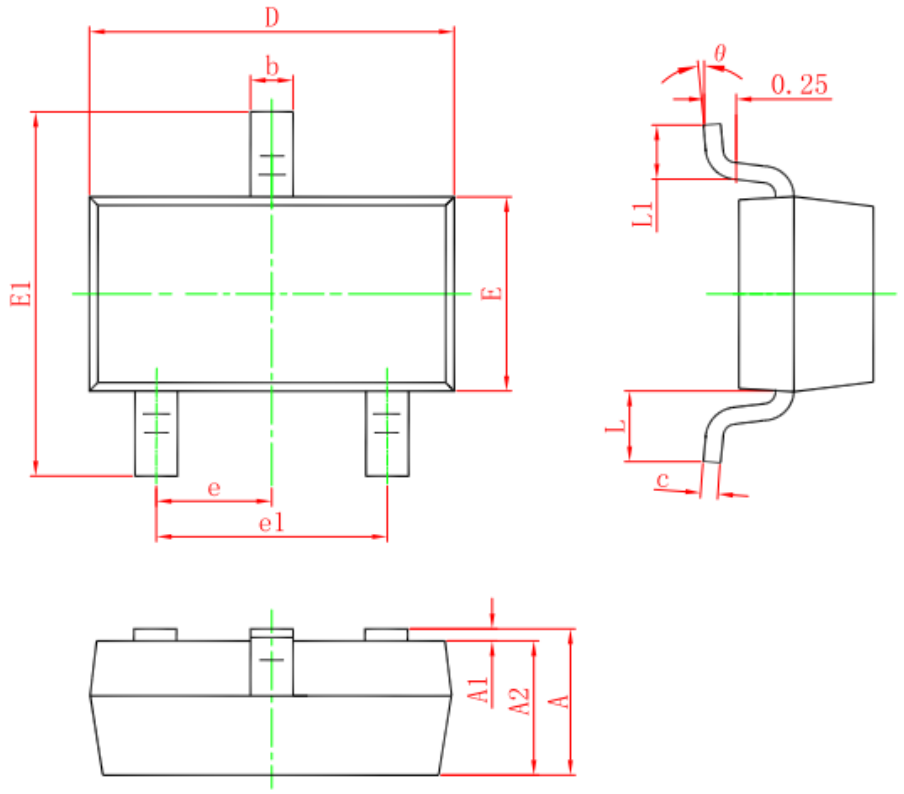
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5.0 PACKAGE INFORMATION

5.1 SOT-23 (3) package

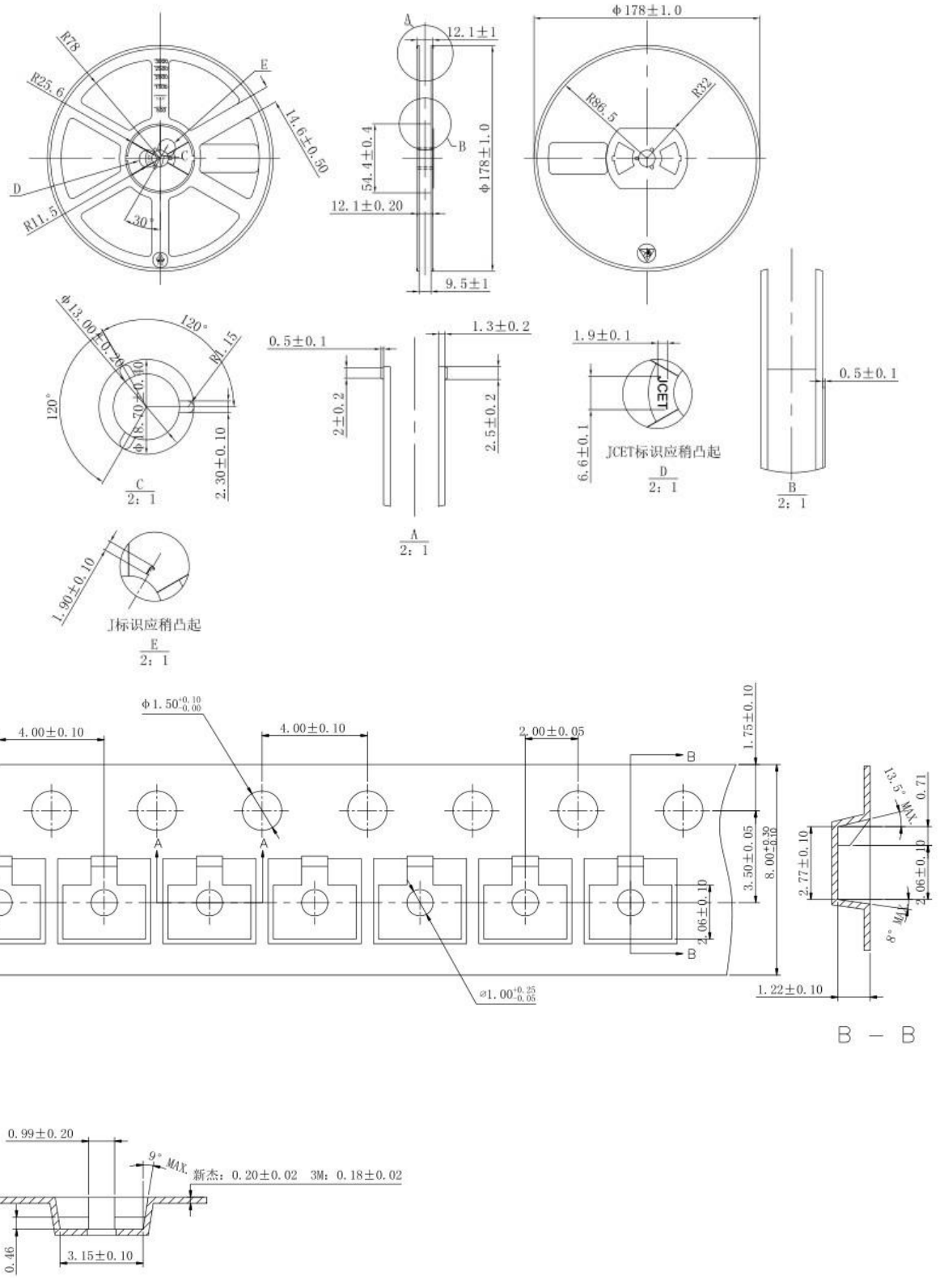
SOT-23 PACKAGE OUTLINE DIMENSIONS



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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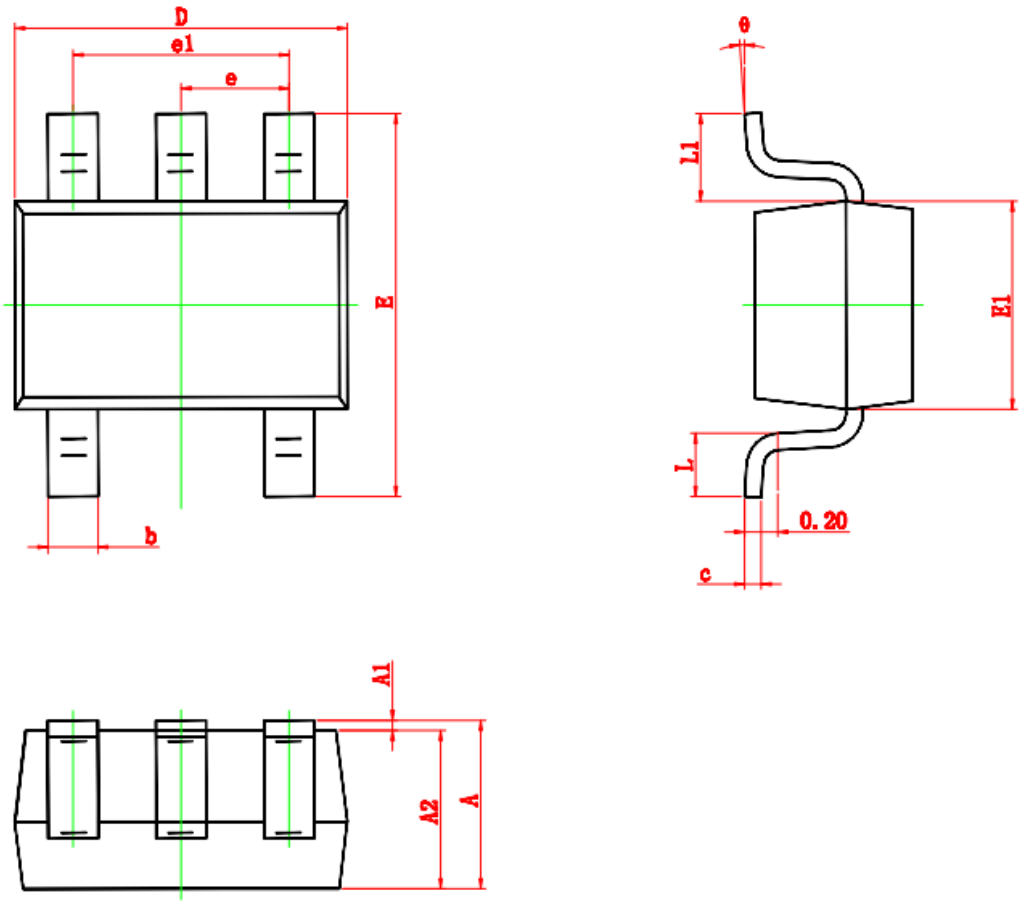


Tape and Reel Information of SOT-23(3)

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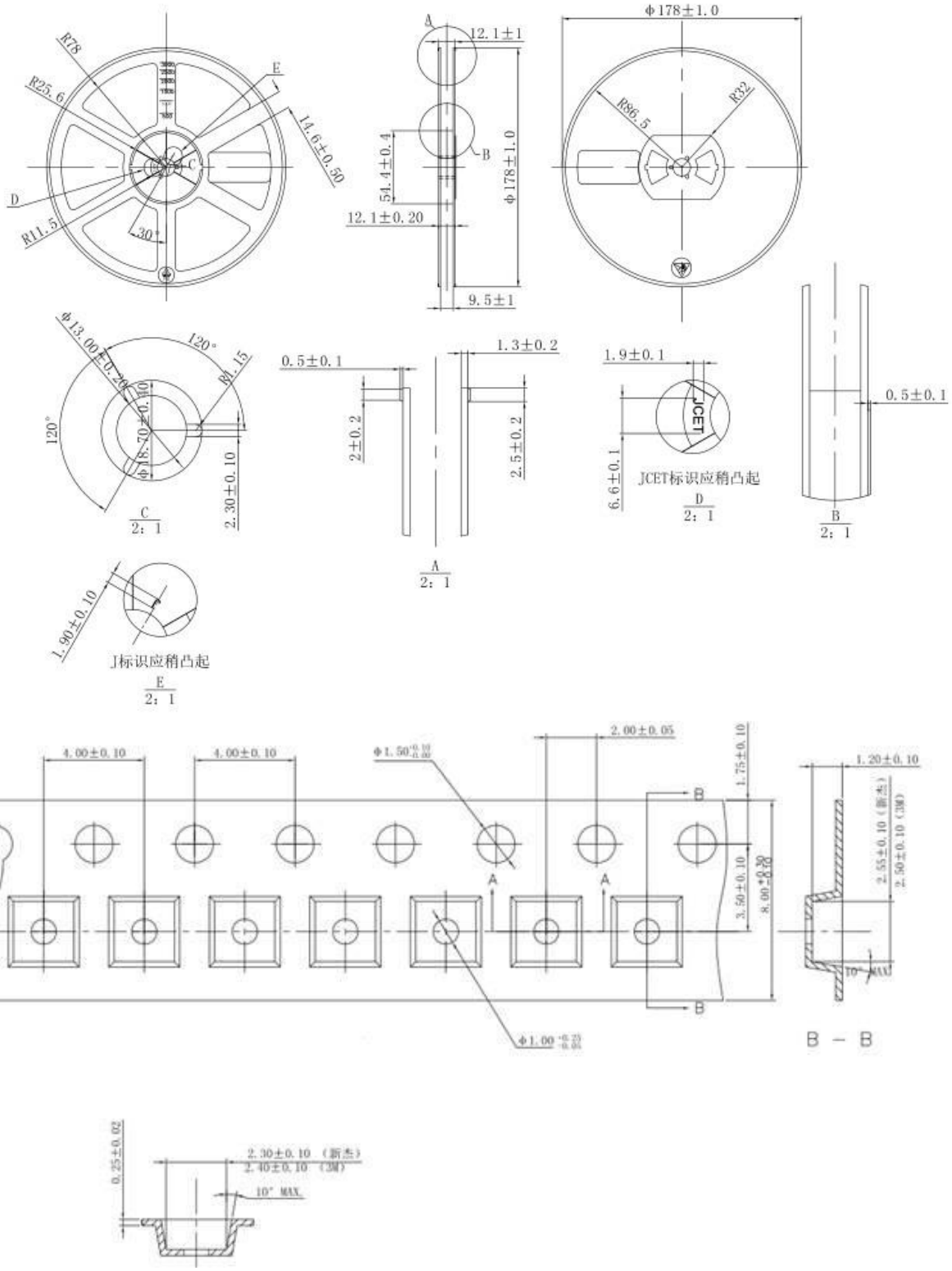
5.2 SC70 (5) package



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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6.0 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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7.0 REVISION HISTORY

Revision	Description	Date
1.0	Initial Version	2020/11/28
1.1	Final Version	2020/01/18

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