NOVOSENSE
纳芯微电子

NST20
±1.5 °C High Precision Ultra-low Current Analog Temperature Sensor

Datasheet (EN) 1.2

Product Overview

The NST20 is a high precision CMOS analog output temperature sensor. The device offers a maximum accuracy of ± 1.5°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 -55°C to 130°C and the power supply operating range is 2.7V to 5.5V, however, the minimum operating voltage can be as low as 2.4V when the temperature range is -30°C to 130°C.

The NST20 device provides a negative slope output of

-11.77mV/°C over -30°C to 100°C. it is highly linear and does not require complex calculations or lookup tables to derive temperature.

The NST20 is a low power device, and the typical operating current is 20µA. Therefore, self-heating is negligible. The NST20 is available in a SC70(5) package, making it suitable for on-board and off-line applications in the industrial, and consumer markets applications in the IoT.

Key Features

- Operating Voltage Range: 2.4V to 5.5V
- Operating Temperature Range: –55°C to 130°C
- Accuracy at 25°C: ±1.5°C (Maximum)
- Accuracy at -55°C to 130°C: ±2.5°C (Maximum)
- Average Sensor Gain: -11.77mV/°C
- Output Impedance: 1 Ω (Typical)
- Operating Current: 20µA (Typical)
- Push-Pull Output Current Drain: 500µA (Maximum)
- Predictable Curvature Error
- Output Short Protection
- Suitable for Remote Applications
- Package: 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*
NST20	SC70(5)	2.00 mm × 1.25 mm

Typical Application

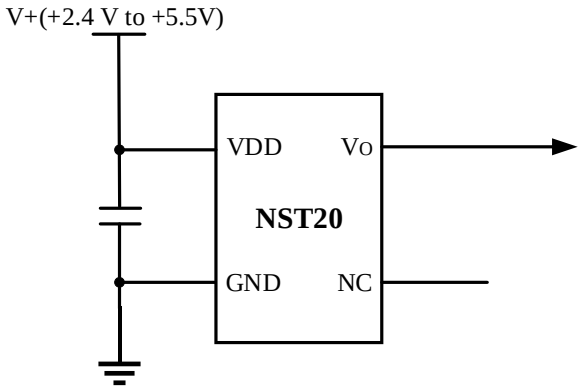


Figure 1 The typical application of NST20

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1 Pin Configuration and Functions

(Top View)

Package:5-Pin SC70

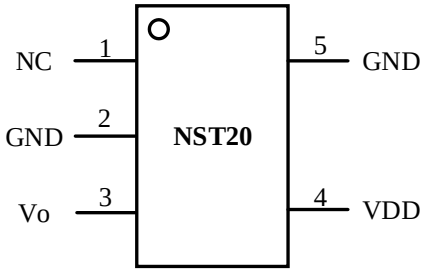


Figure 1.1 NST20 Pin Configuration

Table 1.1 NST20 Pin Function Description

Pinout		*Type*	*Description*
No.	*Name*		
1	NC	—	No Connection
2	GND	GND	Ground pin, connect to power supply negative terminal. This pin must be grounded for optimum thermal conductivity.
3	V_O	Analog Output	Vout (Analog voltage output)
4	VDD	Power	Power supply input pin
5	GND	GND	Ground pin, connect to power supply negative terminal.

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	°C	
Operation Temperature	$TB_{operation}$	-55		130	°C	
Maximum Junction Temperature				155	°C	
ESD Susceptibility	HBM	±4.5			KV	
	CDM	±0.5			KV	

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2.2 Electrical Characteristics

at T_A = +25°C and VDD = +2.4V to +5.5V, unless otherwise noted.

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Supply						
Supply Voltage Range	VDD	2.4		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		-30		130	°C	VDD at 2.4V to 5.5V
		-55		130	°C	VDD at 2.7V to 5.5V
Accuracy $V_O = (-3.88 \times 10^{-6} \times T^2) + (-1.15 \times 10^{-2} \times T) + 1.8639$				±1.5	°C	TA = 25°C to 30°C
				±2.5	°C	TA = 130°C
				±2.5	°C	TA = 125°C
				±2.2	°C	TA = 100°C
				±2.1	°C	TA = 85°C
				±2.0	°C	TA = 80°C
				±1.9	°C	TA = 0°C
				±2.2	°C	TA = -30°C
				±2.3	°C	TA = -40°C
				±2.5	°C	TA = -55°C
Output Voltage at 0°C			1.8639		V	
Vout Drive Capability			500		μA	
Sensor Gain		-12.2	-11.77	-11.4	mV/°C	$-30°C \leq T_A \leq 100°C$
Output Impedance			1		Ω	
Load Regulation			0.5		mV	Source ≤500μA
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	

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

2.3 Typical Characteristics

at VDD = 3.3 V, unless otherwise noted.

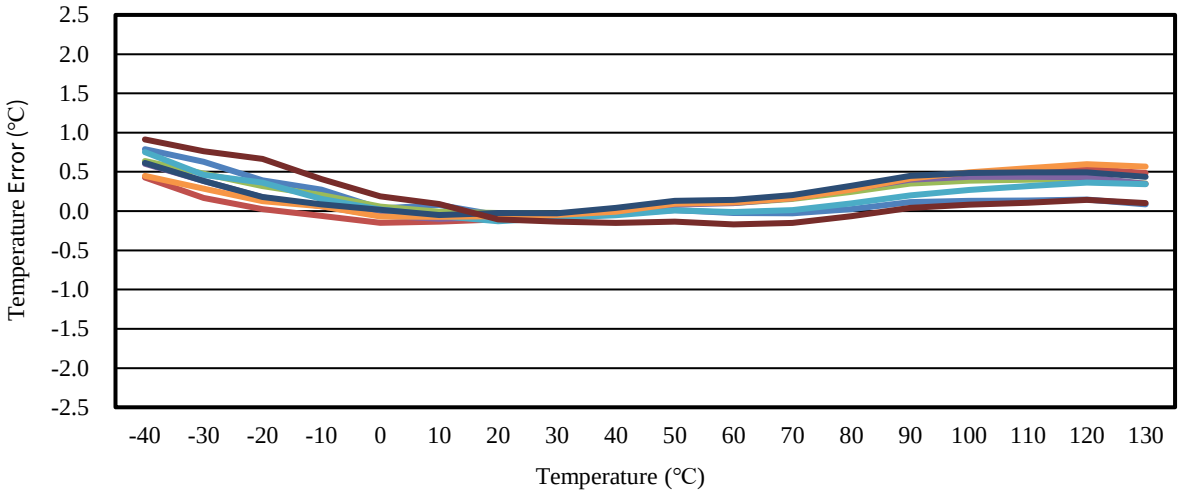


Figure 2.1 Temperature Error vs Temperature

3 Function Description

3.1 Overview

The NST20 is a high precision CMOS analog output temperature sensor. The device offers a maximum accuracy of ± 1.5°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 -55°C to 130°C and the power supply operating range is 2.7V to 5.5V, however, the minimum operating voltage can be as low as 2.4V when the temperature range is -30°C to 130°C.

The NST20 device provides a negative slope output of -11.77mV/°C over -30°C to 100°C. it is highly linear and does not require complex calculations or lookup tables to derive temperature.

The NST20 is a low power device, and the typical operating current is 20μA. Therefore, self-heating is negligible. The NST20 is available in a SC70(5) 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

The NST20 Functional Block Diagram as shown in Figure 3.1.

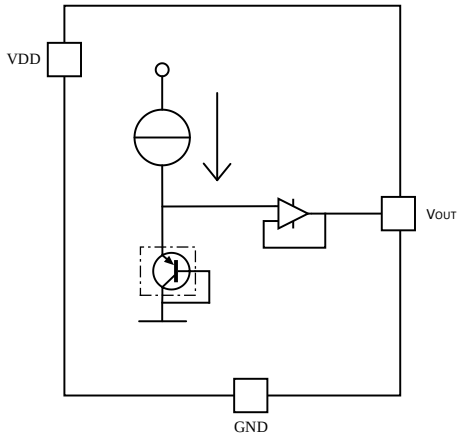


Figure 3.1 NST20 Functional Block Diagram

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3.3 Feature Description

3.3.1 NST20 Transfer Function

The transfer function of NST20 has different accuracy when described in different ways. The transfer function (Equation 3-1) with good accuracy can express the simple linearity of the device near 25° C:

$$V_O = 1.8663V - 11.69mV/℃ \times T \quad (3\text{-}1)$$

The best accuracy is obtained using the quadratic function (Equation 3-2) over the entire operating temperature range of −55°C to 130°C.

$$V_O = 1.8639 + (-1.15 \times 10^{-2} \times T) + (-3.88 \times 10^{-6} \times T^2) \quad (3\text{-}2)$$

The following temperature-voltage output characteristic table (Table 3.1) is derived from Equation 3-2.

Table 3.1 Temperature to Voltage Output Characteristic Table

TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)
-55	2.4847	-28	2.1829	-1	1.8754	26	1.5623	53	1.2435	80	0.9191	107	0.589
-54	2.4736	-27	2.1716	0	1.8639	27	1.5506	54	1.2316	81	0.9069	108	0.5766
-53	2.4625	-26	2.1603	1	1.8524	28	1.5389	55	1.2197	82	0.8948	109	0.5643
-52	2.4514	-25	2.149	2	1.8409	29	1.5271	56	1.2077	83	0.8827	110	0.552
-51	2.4403	-24	2.1377	3	1.8294	30	1.5154	57	1.1958	84	0.8705	111	0.5396
-50	2.4292	-23	2.1263	4	1.8178	31	1.5037	58	1.1838	85	0.8584	112	0.5272
-49	2.4181	-22	2.115	5	1.8063	32	1.4919	59	1.1719	86	0.8462	113	0.5149
-48	2.407	-21	2.1037	6	1.7948	33	1.4802	60	1.1599	87	0.834	114	0.5025
-47	2.3958	-20	2.0923	7	1.7832	34	1.4684	61	1.148	88	0.8219	115	0.4901
-46	2.3847	-19	2.081	8	1.7717	35	1.4566	62	1.136	89	0.8097	116	0.4777
-45	2.3735	-18	2.0696	9	1.7601	36	1.4449	63	1.124	90	0.7975	117	0.4653
-44	2.3624	-17	2.0583	10	1.7485	37	1.4331	64	1.112	91	0.7853	118	0.4529
-43	2.3512	-16	2.0469	11	1.7369	38	1.4213	65	1.1	92	0.7731	119	0.4405
-42	2.3401	-15	2.0355	12	1.7253	39	1.4095	66	1.088	93	0.7608	120	0.428
-41	2.3289	-14	2.0241	13	1.7137	40	1.3977	67	1.076	94	0.7486	121	0.4156
-40	2.3177	-13	2.0127	14	1.7021	41	1.3859	68	1.064	95	0.7364	122	0.4032
-39	2.3065	-12	2.0013	15	1.6905	42	1.3741	69	1.0519	96	0.7241	123	0.3907
-38	2.2953	-11	1.9899	16	1.6789	43	1.3622	70	1.0399	97	0.7119	124	0.3782
-37	2.2841	-10	1.9785	17	1.6673	44	1.3504	71	1.0278	98	0.6996	125	0.3658
-36	2.2729	-9	1.9671	18	1.6556	45	1.3385	72	1.0158	99	0.6874	126	0.3533
-35	2.2616	-8	1.9557	19	1.644	46	1.3267	73	1.0037	100	0.6751	127	0.3408
-34	2.2504	-7	1.9442	20	1.6323	47	1.3148	74	0.9917	101	0.6628	128	0.3283

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Table 3.1 Temperature to Voltage Output Characteristic Table (Continued)

TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)	TEMP (℃)	VOUT (V)
-33	2.2392	-6	1.9328	21	1.6207	48	1.303	75	0.9796	102	0.6505	129	0.3158
-32	2.2279	-5	1.9213	22	1.609	49	1.2911	76	0.9675	103	0.6382	130	0.3033
-31	2.2167	-4	1.9098	23	1.5973	50	1.2792	77	0.9554	104	0.6259	—	—
-30	2.2054	-3	1.8984	24	1.5857	51	1.2673	78	0.9433	105	0.6136	—	—
-29	2.1941	-2	1.8869	25	1.574	52	1.2554	79	0.9312	106	0.6013	—	—

T can be obtained from Equation (3-2):

$$T = -1481.96 + \sqrt{\frac{(1.8639 - V_O)}{3.88 \times 10^{-6}} + 2.1962 \times 10^{6}} \quad (3\text{-}3)$$

3.3.2 Application Curve

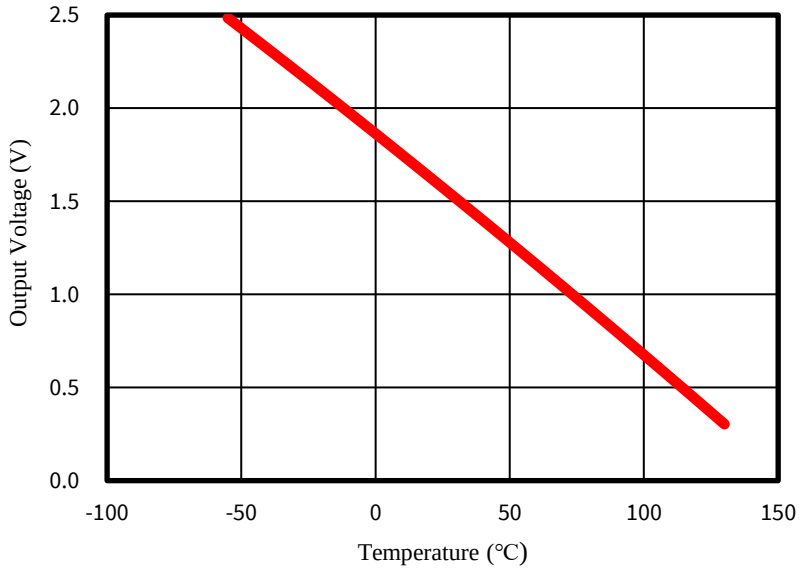


Figure 3.2 Output Voltage vs Temperature

4 Application Information

4.1 Capacitive Loads

As shown in the structure diagram, the output stage of NST20 is an amplifier. Generally, the output of the amplifier directly connected to the capacitive load is unstable. However, NST20 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 NST20 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 NST20, such as a 1μF capacitor and a 200Ω series resistor. This low-pass filter will improve the thermal response time of NST20 and has the function of filtering high-frequency noise as shown in the Figure 4.2.

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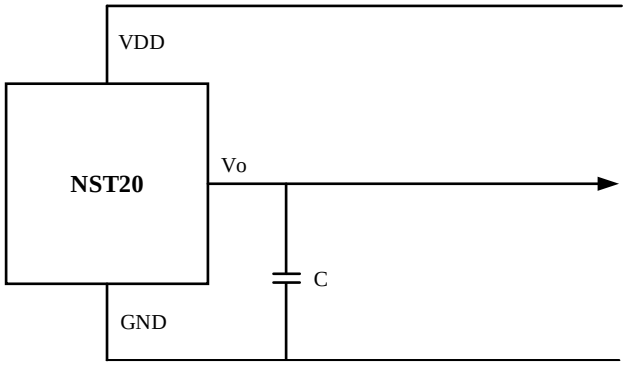


Figure 4.1 NST20 No Decoupling Required for Capacitive Loads Less Than 1000 pF

Table 4.1 Capacitive Loading Isolation

C(μF)	Minimum R(Ω)
1	200
0.1	470
0.01	680
0.001	1000

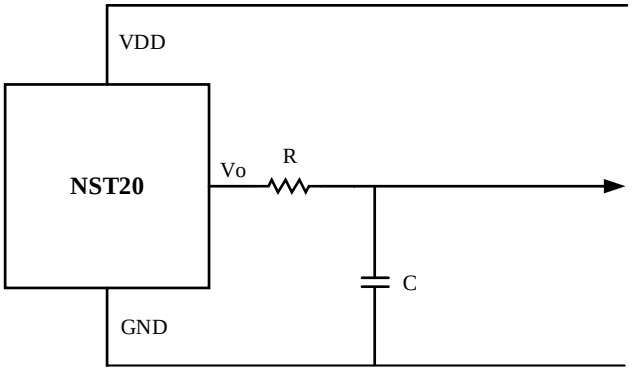


Figure 4.2 NST20 with RC Filter

4.2 Typical Application

As shown in Figure 4.3, the NST20 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.

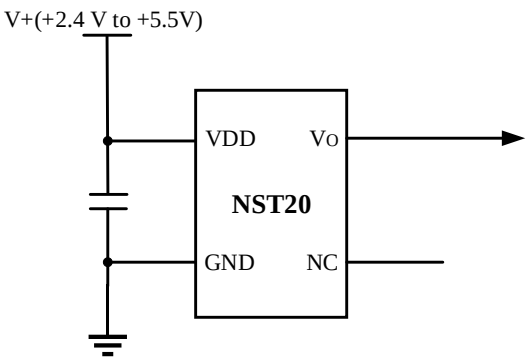


Figure 4.3 Typical Connections of the NST20

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4.3 System Examples

4.3.1 Conserving Power Dissipation with Shutdown

Although NST20 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.

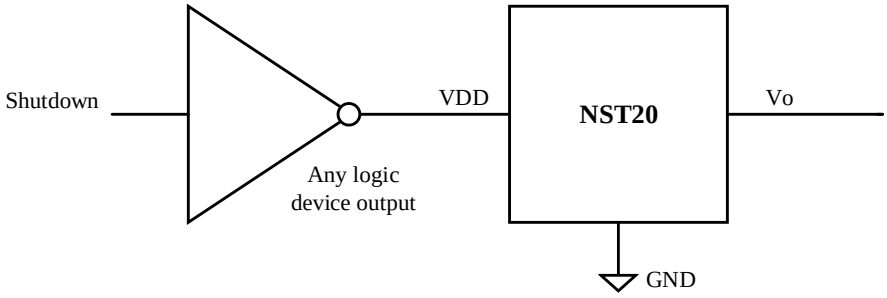


Figure 4.4 Conserving Power Dissipation with Shutdown

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 NST20 temperature sensor and many operational amplifiers). By adding RC filter to the output stage of NST20, 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.

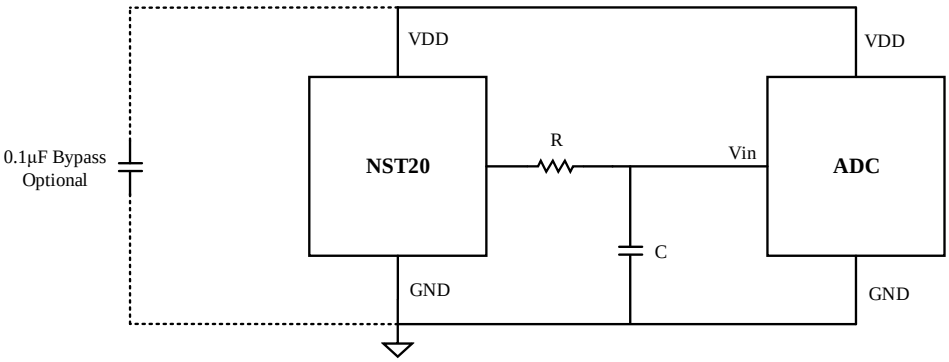


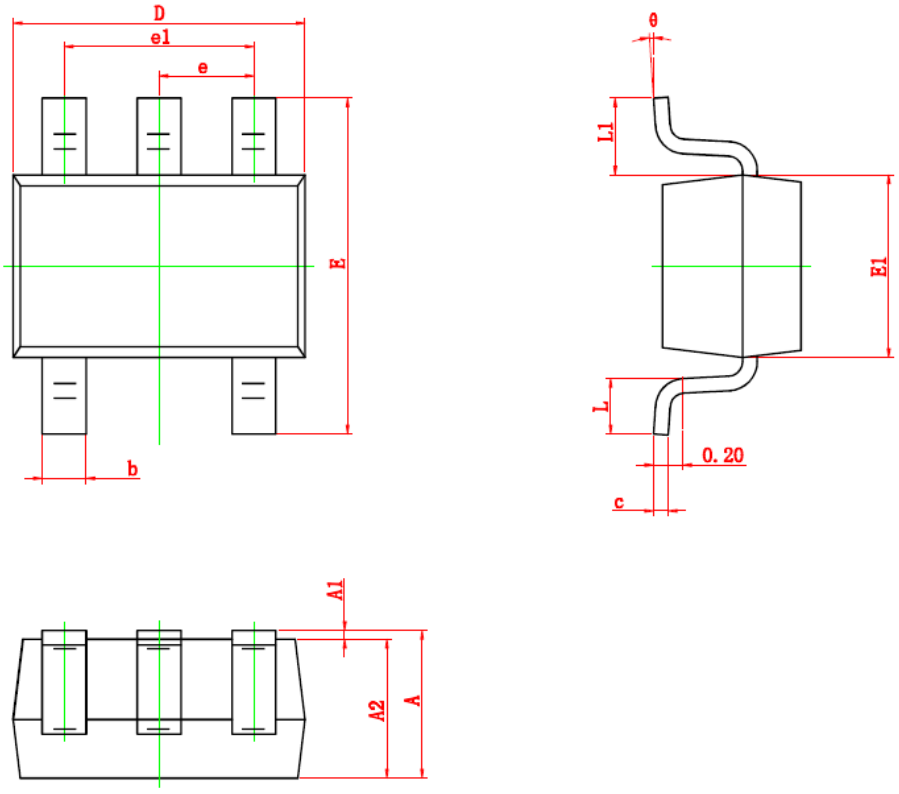
Figure 4.5 Suggested Connection to a Sampling Analog to Digital Converter Input Stage

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5 Package Information

5.1 SC70(5) Package

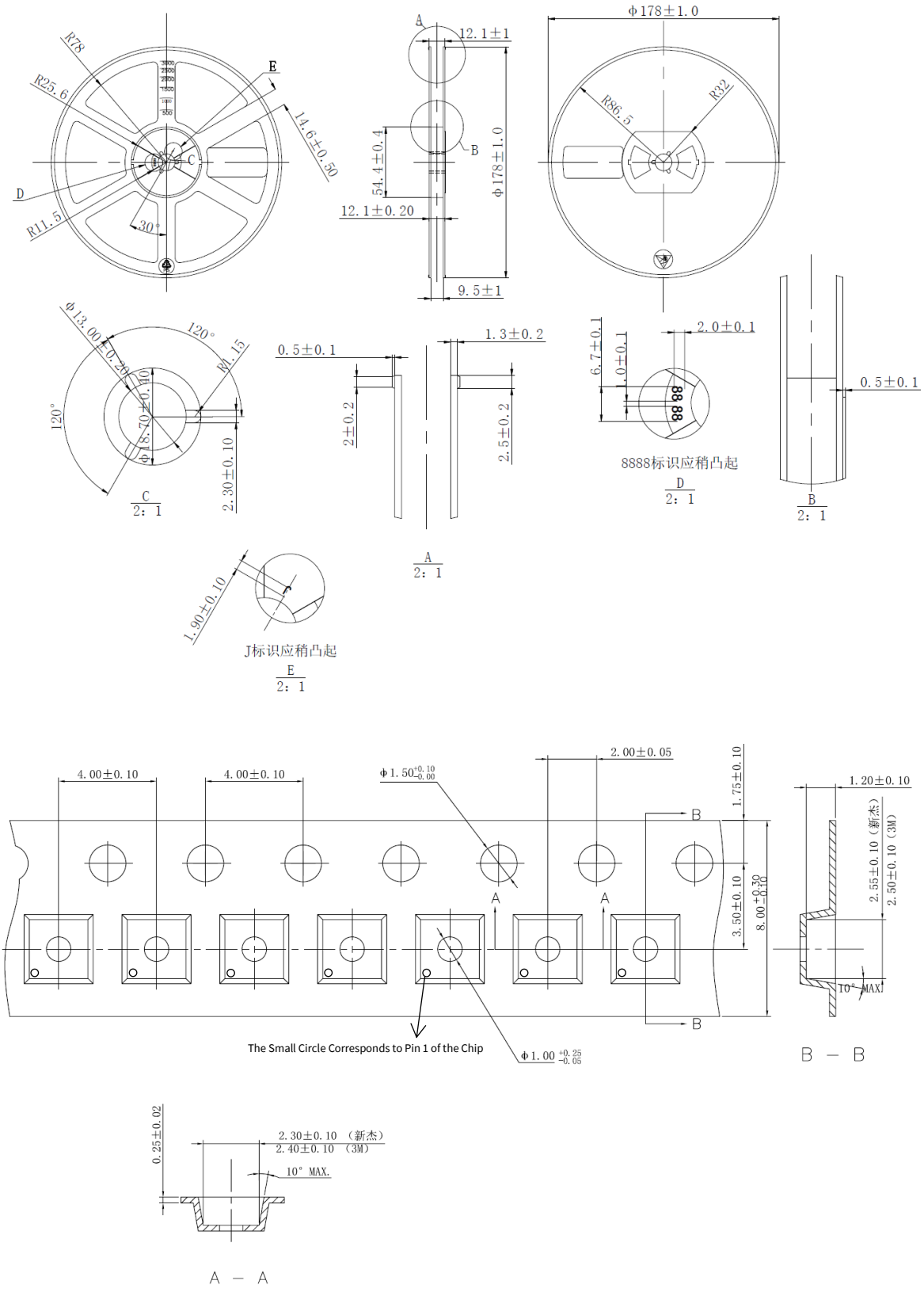


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.900	1.100	0.035	0.043
A1	0.000	0.100	0.000	0.004
A2	0.900	1.000	0.035	0.039
b	0.150	0.350	0.006	0.014
c	0.110	0.175	0.004	0.007
D	2.000	2.200	0.079	0.087
E	2.150	2.450	0.085	0.096
E1	1.150	1.350	0.045	0.053
e	0.650 TYP.		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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5.2 SC70(5) Package Tape & Reel



Tape and Reel Information of SC70(5)

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6 Order Information

Type	*Unit*	*MSL*	*Marking*	*Description*
NST20H-DSCR	3000ea/Reel	1	20YXX	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	2020/03/12
1.1	Revise Accuracy information. Optimize text presentation	2022/03/30
1.2	Update Functional Description. Update Pin Configuration Diagram. Update Load Regulation of Electrical Characteristics. Change Application Information.Tape and reel show 1 pin. Optimize Text Presentation.	2022/08/02

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