NST1002(D-NTC®)

±0.1°C High Accuracy Temperature Sensor with One-Wire

Datasheet (EN) 1.0

Description

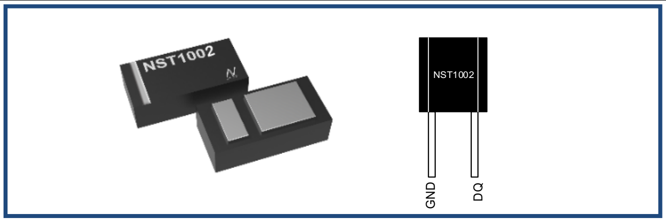
The NST1002 is a NOVOSENSE D-NTC® series digital temperature sensor compatible with One-Wire interface which makes it possible to directly connect to the GPIO of the MCU and save MCU resources to the greatest extent.

The NST1002 has a high accuracy and high resolution over temperature range of -50°C to 150°C. The on-chip 15bit ADC offers resolutions down to 0.0078125°C. The devices offer a typical accuracy of ±0.1°C without requiring calibration and are highly linear and do not require complex calculations or look-up tables.

NST1002 suits automotive, industrial, home appliances and other applications for temperature monitoring, which can be easily used as a two wire digital temperature probe or as a direct replacement for NTC thermistors. NST1002 can also be used in wireless IoT sensor nodes with particularly stringent power requirements because of its extremely low operating current, which can be powered through the MCU's GPIO. The NST1002 is available in an DFN-2L and TO-92S-2L package.

Features

- High Accuracy Over –50°C to 150°C
  - DFN-2L
    0°C ~ 85°C: ±0.1°C (Typ) ±0.25°C (Max)
    -40°C ~ 125°C: ±0.5°C (Max)
    -40°C ~ 150°C: ±0.5°C (Max) @3.3V
  - TO-92S-2L
    0°C ~ 85°C: ±0.2°C (Typ)
    -20°C ~ 85°C: ±0.35°C (Max)
    -40°C ~ 125°C: ±0.7°C (Max)
    -40°C ~ 150°C: ±0.7°C (Max) @3.3V
- Higher Resolution with 0.0078125°C (1 LSB)
- Date Conversion and Transmission: 32ms/period



- Supply Operation Range from 1.7V to 5.5V
- Physically Pin to Pin Replace NTC Devices
- Conversion Current: 30uA (Typical)
- Idle Current: 5.4μA (Typical)

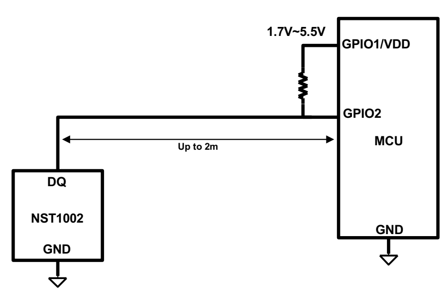
Applications

- Digital Output Wired Probes
- General System Thermal Management
- Computer Peripheral Thermal Protection
- Notebook Computers
- Industrial Internet of Things (IoT)
- Communications Infrastructure
- Power-system Monitors
- Thermal Protection
- Environmental Monitoring and HVAC
- Medical devices

Device Information

Part Number	Package	Body Size
NST1002-CDNR	DFN-2L	1.6mm × 0.8mm
NST1002-QTZB	TO-92S-2L	4.0mm x 3.0mm

Typical Application



Typical Application of NST1002

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1.Pin Configuration and Functions

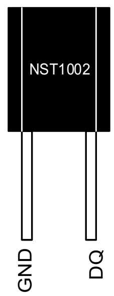


Figure 1.1 NST1002(TO-92S-2L) Pin Configuration

Table 1.1 TO-92S-2L Pin function

Pinout		***Type***	***Description***
Name	***No.***		
DQ	1	I/O	Supply and digital IO
GND	2	GND	GND

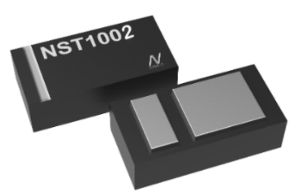


Figure 1.2 NST1002 Pin Configuration (DFN-2L)

Table 1.2 DFN-2L Pin function

Pinout		***Type***	***Description***
Name	***No.***		
DQ	1	I/O	Supply and digital IO
GND	2	GND	GND (widely pad)

2.Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit	Comments
DQ voltage	V_{DQ}	-0.3		6.5	V	
Storage temperature		-60		155	°C	
Operation temperature	$TB_{operation}$	-50		150	°C	
Maximum junction temperature				155	°C	

3.ESD Ratings

Parameters	Symbol	Value	Unit
Electrostatic discharge(ESD)	Human Body Model (HBM)(1)	±8000	V
	Charged Device Model (CDM)(2)	±2000	V

(1) Refer to *ESDA/JEDEC JS-001-2017*

(2) Refer to *ESDA/JEDEC JS-002-2018*

4.Specifications

4.1.Electrical Characteristics

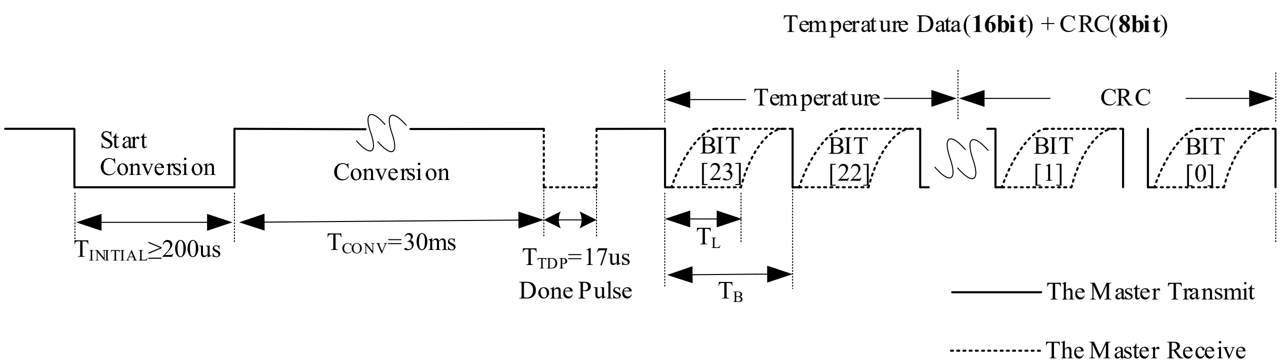
at T_A = +25°C and V_{pu} = +1.7V to +5.5V, Pull up resistor 4.7kohm, unless otherwise noted.

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Supply						
Supply voltage Range	V_{pu}	1.7		5.5	V	
Supply sensitivity			15		m°C /V	
Operation current	I_{CONV}		30		μA	Conversion
	I_{IDLE}		5.4		μA	Communication
Temperature Range and Resolution						
Temperature Range		-50		150	°C	
Resolution			0.0078125		°C	
Accuracy			±0.1	±0.25	°C	From 0°C to 85°C @DFN-2L
				±0.5	°C	From -40°C to 125°C @DFN-2L
				±0.5	°C	From -40°C to 150°C @3.3V, DFN-2L
			±0.2		°C	From 0°C to 85°C @TO-92S-2L
				±0.35	°C	From -20°C to 85°C @TO-92S-2L
				±0.7	°C	From -40°C to 125°C @TO-92S-2L
				±0.7	°C	From -40°C to 150°C @3.3V, TO-92S-2L
Pulse count transfer function						
High-level input logic	V_H	V_{pu}-0.3			V	
Low-level input logic	V_L			0.2	V	

Parasitic Cap in DQ Pin	C_{DQ}			$2/R_{pu}$	µF	When R_{pu}=5kohm, C_{DQmax}=400pF
Reset time when DQ pull down						
Reset time when DQ pull down	T_{RST}			5	ms	NST1002 will pull down if DQ pull down more than 5ms
Thermal response						
Thermal Response			0.27		s	Stirred Oil Thermal Setting to 63% of Final Value @DFN-2L
Drift						
Drift (1)			0.04		°C	@DFN-2L

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

4.2.Timing Diagram



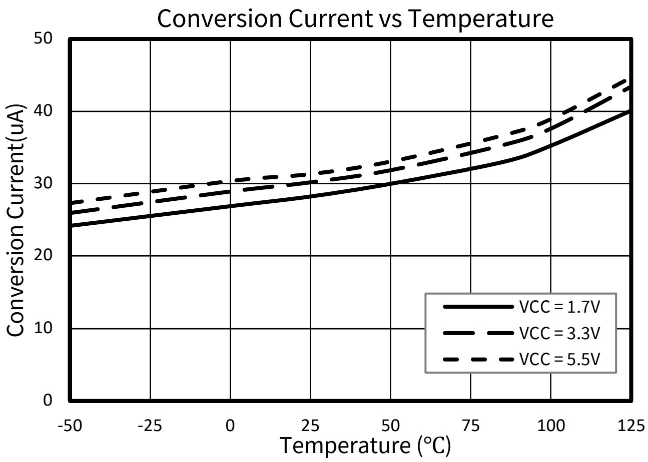
4.3.Timing Characteristics

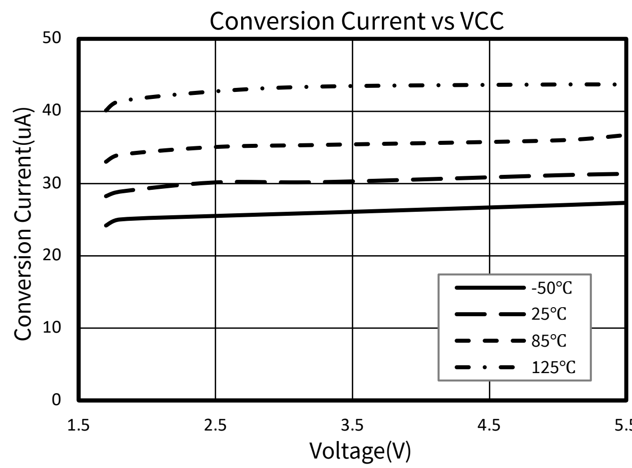
at T_A = +25°C and V_{pu} = 3.3V, Pull up resistor 4.7kohm, unless otherwise noted.

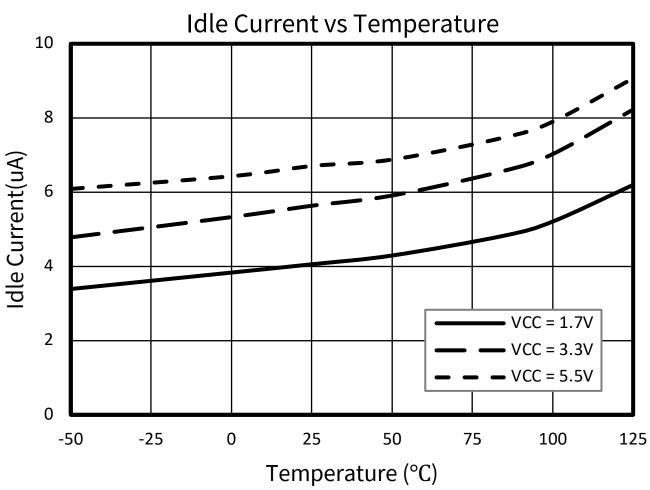
Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Start conversion	$T_{INITIAL}$	200			µs	
Conversion time	T_{CONV}		30		ms	
Temperature done pulse	T_{TDP}		17		µs	
Single bit data time	T_L		16		µs	
Single bit period time	T_B	60			µs	

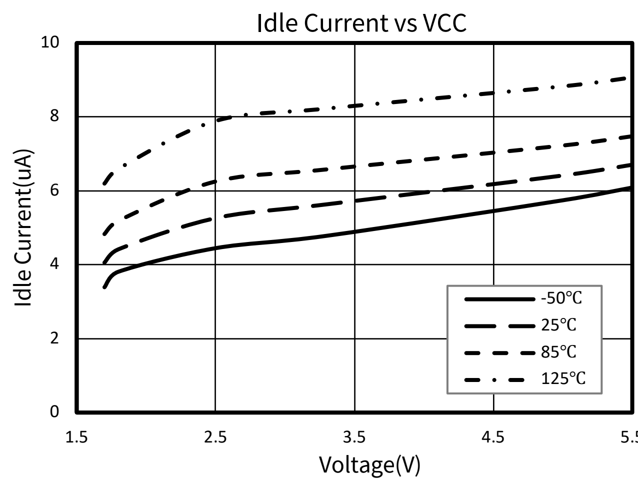
4.4.Typical Characteristics

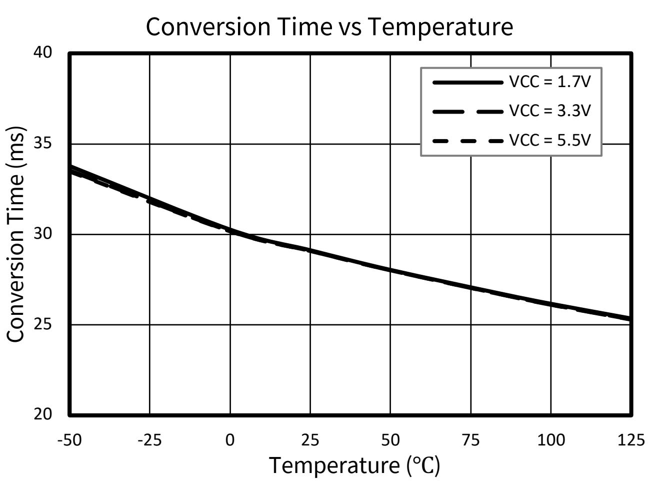
at T_A = +25°C and V_{pu} = 3.3 V, thermal response test with T(initial) = 25°C, T(final) = 100°C, unless otherwise noted.

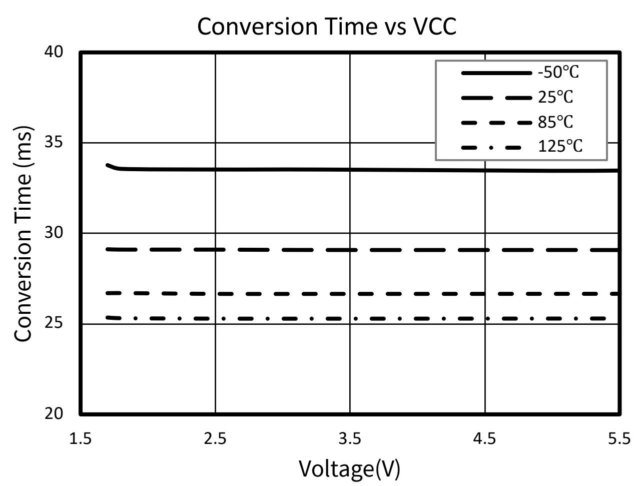


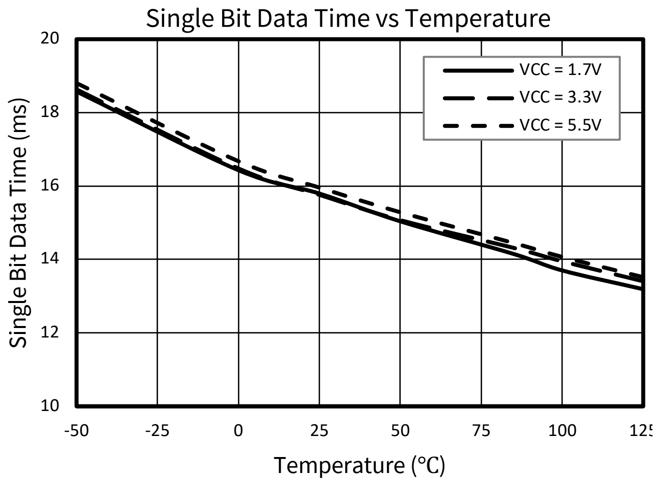


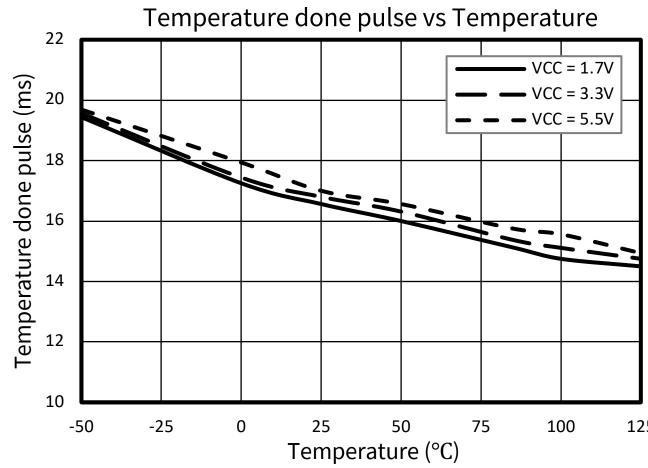


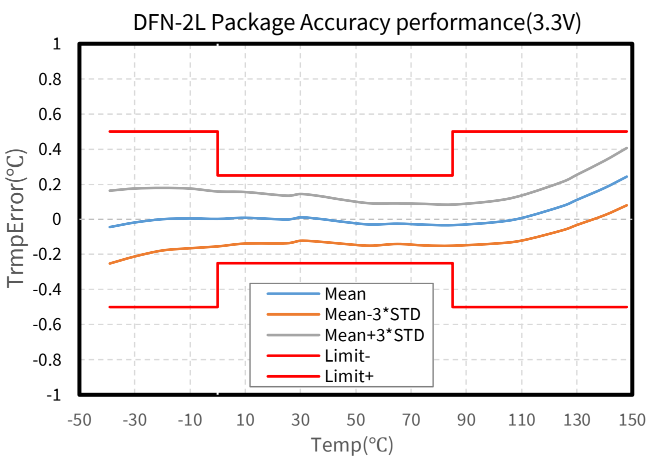


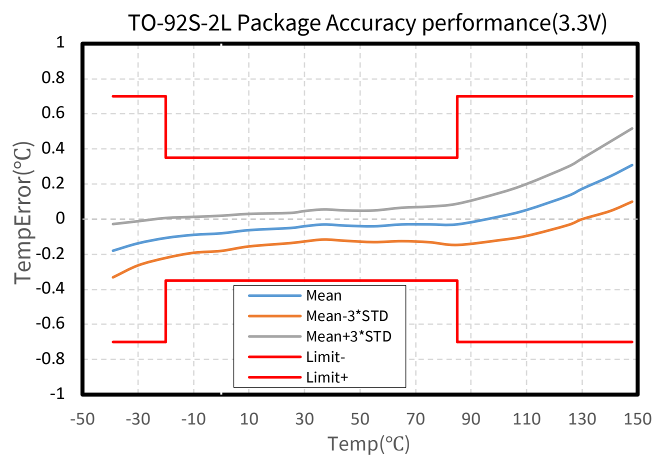


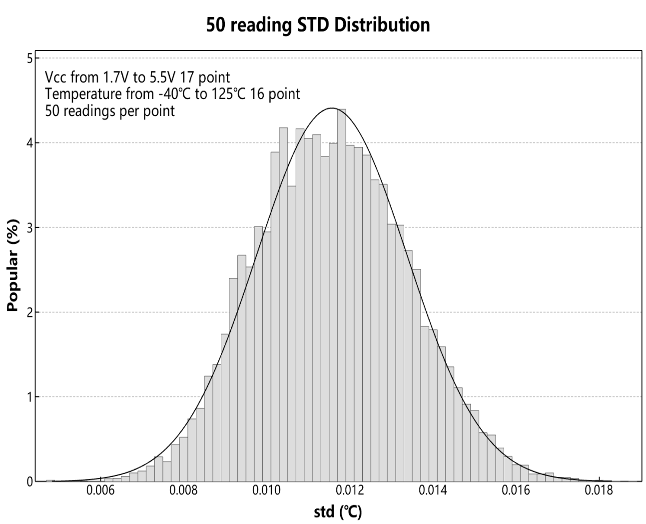


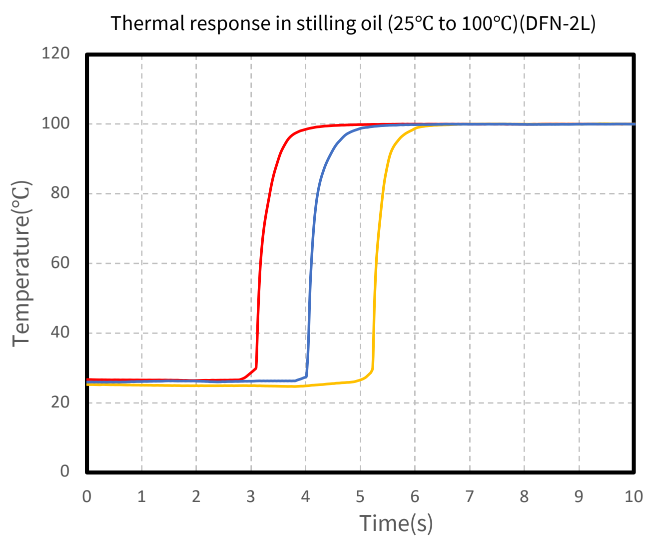

Single Bit Data Time vs Temperature
Single Bit Data Time (ms)
Temperature (℃)
VCC = 1.7V
VCC = 3.3V
VCC = 5.5V


Temperature done pulse vs Temperature
Temperature done pulse (ms)
Temperature (℃)
VCC = 1.7V
VCC = 3.3V
VCC = 5.5V


DFN-2L Package Accuracy performance(3.3V)
TrmpError(℃)
Temp(℃)
Mean
Mean-3*STD
Mean+3*STD
Limit-
Limit+


TO-92S-2L Package Accuracy performance(3.3V)
TempError(℃)
Temp(℃)
Mean
Mean-3*STD
Mean+3*STD
Limit-
Limit+


50 reading STD Distribution
Vcc from 1.7V to 5.5V 17 point
Temperature from -40℃ to 125℃ 16 point
50 readings per point
Popular (%)
std (℃)


Thermal response in stilling oil (25℃ to 100℃)(DFN-2L)
Temperature(℃)
Time(s)

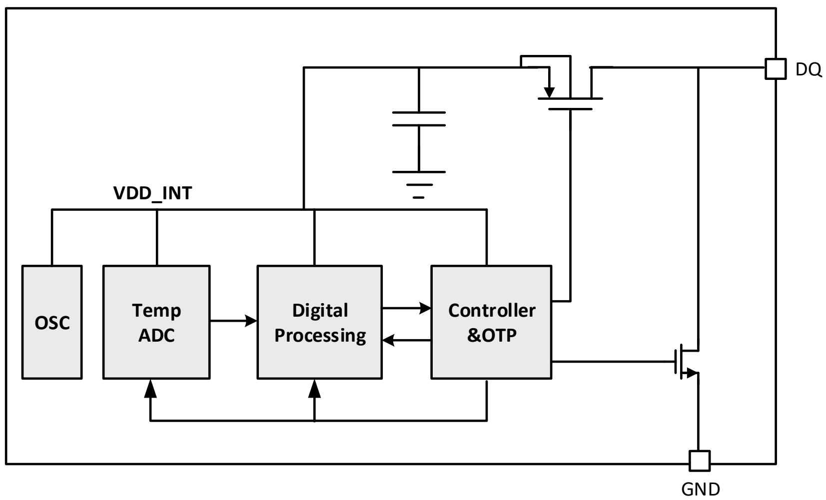
5.Function Description

5.1.Overview

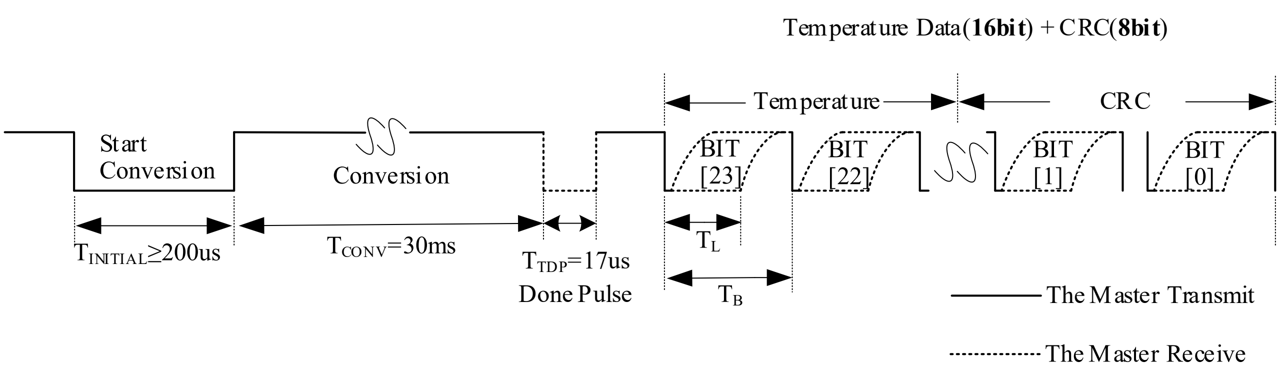
The NST1002 is a 1.7V to 5.5V micropower digital temperature sensor and include a PNP-BJT type temperature sensor and 15bit ADC (∑-ΔADC). The device is specified at the full temperature range of -50 °C to 150 °C with a 0.0078125°C resolution. The NST1002 communicates through a flexible One-wire digital interface. Each NST1002 device was calibrated before delivery with OTP, so the device has very high accurate in Operation range. The NST1002 is almost no self-heat, since conversion current of the device is 30μA and idle current is only 5.4μA.

NST1002 suits automotive, industrial, home appliances and other applications for temperature monitoring, which can be easily used as a two-wire digital temperature probe or as a direct replacement for NTC thermistors. NST1002 can also be used in wireless IoT sensor nodes with particularly stringent power requirements because of its extremely low operating current, which can be powered through the MCU's GPIO. The NST1002 is available in an DFN-2L and TO-92S-2L package.

5.2.Functional Block Diagram



5.3.One-Wire Communication



Initialization:

The host (as MCU) sends a low pulse that lasts at least 200μs to initialize the device. After initialization, the device is ready for start temperature conversion. If the initialization is incorrect, such as the low pulse time is too short, the device will not perform temperature conversion and will remain idle state. It should be noted that when the device is in the idle state, in order to read the temperature normally, the host must pull up the DQ pin and wait at least 30ms before initialization.

Temperature conversion:

After the successful initialization of the device, it will enter in the temperature conversion stage. This process needs to ensure that the DQ pin is at a high level and lasts for 30ms (typical), and it will not be interrupted until finishing temperature conversion.

Temperature Done Pulse:

After the device completes the temperature conversion, it will send a low pulse lasting 17us (typical), this means that the temperature conversion is successful, meanwhile the host should configure the DQ pin as the input mode to read the Temperature Done Pulse, then prepare to read the data.

Read Out Data(Temperature data and CRC check data):

After completing the above series of operations, the host can read data bit by bit (including temperature data and CRC data). It should be noted that single bit data time(T_L) and single bit period time (T_B) during reading and pulling down DQ before reading each bit of data (Please refer to Section 3.3 for specific time), and after data reading is completed, the device enters in the idle state. The detailed data format will be described in Section 4.4.

5.4.Digital Temperature Data

The resolution of NST1002 is 15bit, and 1LSB corresponding to 0.0078125°C. After the conversation, the Temperature data can be read from DQ pin with a total 24bit data (16bit temperature data + 8bit CRC check data), and MSB firstly. The digital output from each temperature measurement conversion is stored in the Temperature register as 15bit sign-extend complement format. The sign bit(S) indicate if the temperature is positive or negative: for positive number S=0 and for negative number S=1. Data format of temperature is listed in Table 5.1 and Table 5.2. Negative numbers are represented in binary complement format.

Table 5.1Temperature Data Format Description

BIT	***BIT23***	***BIT22***	***BIT21***	***BIT20***	***BIT19***	***BIT18***	***BIT17***	***BIT16***	***BIT15***
Define	S	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Description	Sign	128	64	32	16	8	4	2	1
BIT	***BIT14***	***BIT13***	***BIT12***	***BIT11***	***BIT10***	***BIT9***	***BIT8***	***BIT7***	***BIT6***
Define	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	CC7	CC6
Description	0.5	0.25	0.125	0.0625	0.03125	0.015625	0.0078125	CRC check	CRC check
BIT	***BIT5***	***BIT4***	***BIT3***	***BIT2***	***BIT1***	***BIT0***	-	-	-
Define	CC5	CC4	CC3	CC2	CC1	CC0	-	-	-
Description	CRC check	CRC check	CRC check	CRC check	CRC check	CRC check	-	-	-

Note: The BIT0 to BIT7 is the CRC check bit.

The error detection scheme most effective at locating errors in a serial-data stream with a minimal amount of hardware is the CRC. The NST1002 uses the standard CRC model that size is 8bit, which is used to check the correctness of each bit of temperature data and the specific polynomial is shown in Equation 4-1:

$$CRC = X^8 + X^5 + X^4 + 1 \tag{4-1}$$

Note： The original data and calculated data needs to be flipped.

Table 5.2 Temperature Data Format (excluding CRC check bit)

TEMPERATURE (℃)	***DIGITAL OUTPUT***	
	BINARY	***HEX***
150.9921875	0100 1011 0111 1111	4B7F
127.9921875	0011 1111 1111 1111	3FFF
100	0011 0010 0000 0000	3200
25	0000 1100 1000 0000	0C80
0	0000 0000 0000 0000	0000
-0.1953125	1111 1111 1110 0111	FFE7
-25	1111 0011 1000 0000	F380
-50	1110 0111 0000 0000	E700

6.Typical Application

The NST1002 can work in the parasitic power mode. When the bus is at a high level, power is supplied through One-Wire pull-up resistor. The high bus signal also charges the internal capacitors and then supplies power to the device when the bus is low. It should be noted that when the device is in the idle state, in order to read the temperature normally, the host must pull up the DQ pin and wait at least 30ms before initialization.

6.1.Single GPIO Application

As shown in Figure 6.1, the pinout DQ connect to GPIO and also connect to VDD with pull up resistor Rpu. The output pulse of the device can be read with a GPIO. There is only 1 GPIO needed in this application, saving the GPIO resource in the system. NST1002 will pull down if DQ pull down the GPIO more than 5ms.

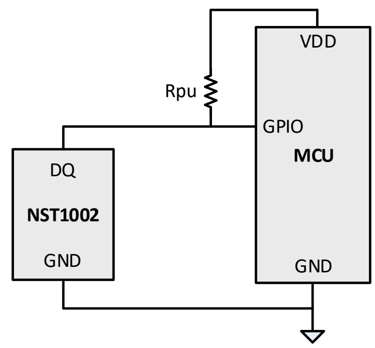


Figure 6.1 Single GPIO application

Table 6.1 Design parameter

Design parameter	***Value***
R_{pu}	1 KΩ~10KΩ
VDD	1.7V~5.5V
Microcontroller	General I/O

Note: the NST1002 max Conversion current is 30μA (typical), and the min Operation voltage will be effected by pull up resistor R_{pu}. For example, the min Operation voltage is 1.7V while the R_{pu} =5KΩ.

6.2.No power consumption in standby mode application

There are 2 GPIO needed in this application in order to achieve the no power consumption in standby mode. As shown in Figure 6.2, the DQ pin connected to GPIO2 and connects to GPIO1 with pull up resistor Rpu. The GPIO1 will set to high, and provide the power though the pull up resistor Rpu as VDD. The GPIO2 as One-Wire communication pin to get temperature data. If the temperature is calculated, and pulls down the GPIO1, there is no power consumption in standby mode.

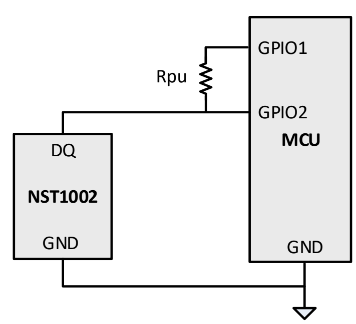


Figure 6.2 No power consumption in standby mode application

6.3.Multi-point Temperature Acquisition

As shown in Figure6.3, all NST1002 nodes in this scheme share GPIO0 as the DQ count port and share the same pull-up resistor. The temperature node to be acquired is enabled by pulling one of GPIO1~GPIOn low, and the GPIO corresponding to the other unused nodes is set to high resistance state. Note that more than two of GPIO1~GPIOn cannot be pulled low at the same time.

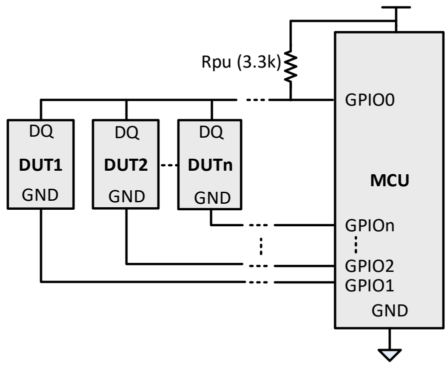
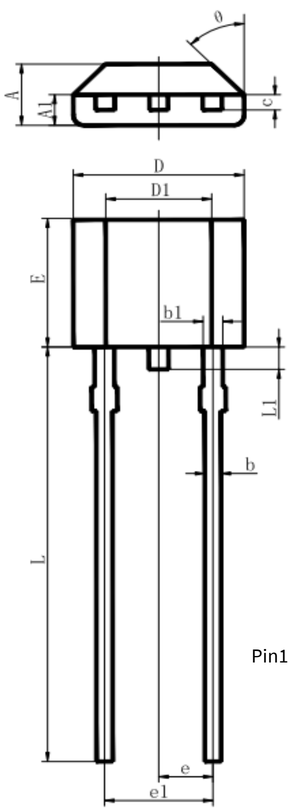


Figure 6.3 Multi-point temperature acquisition with NST1002

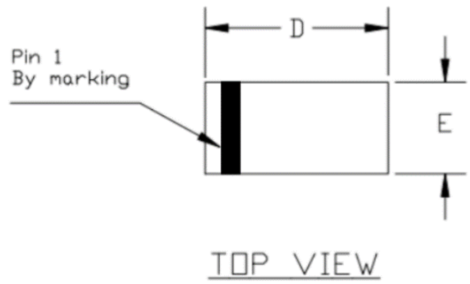
7.Package Information

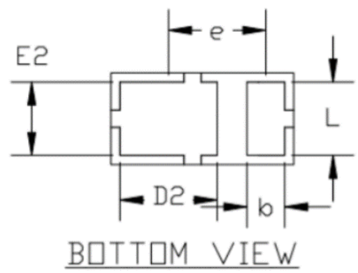
7.1.TO-92S-2L package

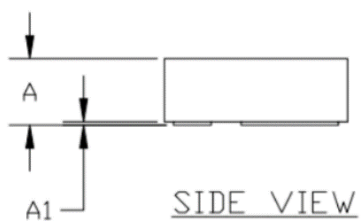


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.420	1.620	0.056	0.064
A1	0.660	0.860	0.026	0.034
b	0.330	0.480	0.013	0.019
b1	0.400	0.510	0.016	0.020
c	0.330	0.510	0.013	0.020
D	3.900	4.100	0.154	0.161
D1	2.280	2.680	0.090	0.106
E	3.050	3.250	0.120	0.128
e	1.270 TYP.		0.050 TYP.	
e1	2.440	2.640	0.096	0.104
L	15.100	15.500	0.594	0.610
L1	0.350	0.650	0.014	0.026
θ	45° TYP.		45° TYP.	

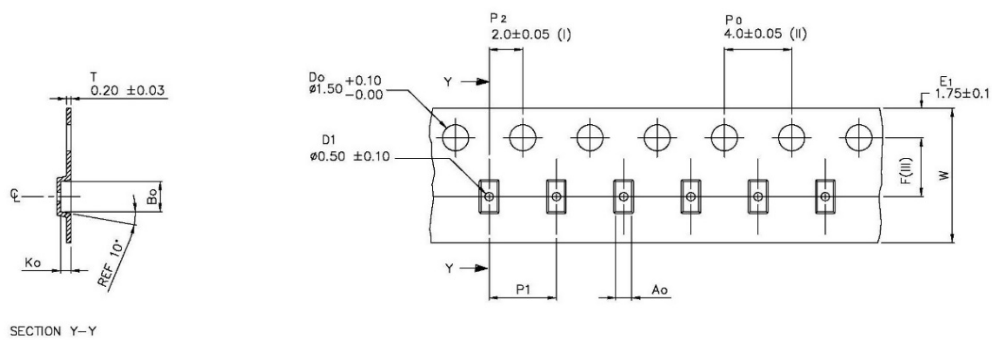
7.2.DFN-2L Package







COMMON DIMENSIONS(MM)			
PKG.	X1: EXTREME THIN		
REF.	MIN.	NOM.	MAX
A	0.40	0.45	0.50
A1	0.00	–	0.05
A3	0.125 REF.		
D	1.55	1.60	1.65
E	0.75	0.80	0.85
D2	0.75	0.85	0.95
E2	0.54	0.64	0.74
L	0.54	0.64	0.74
b	0.28	0.33	0.41
e	0.85 BSC		

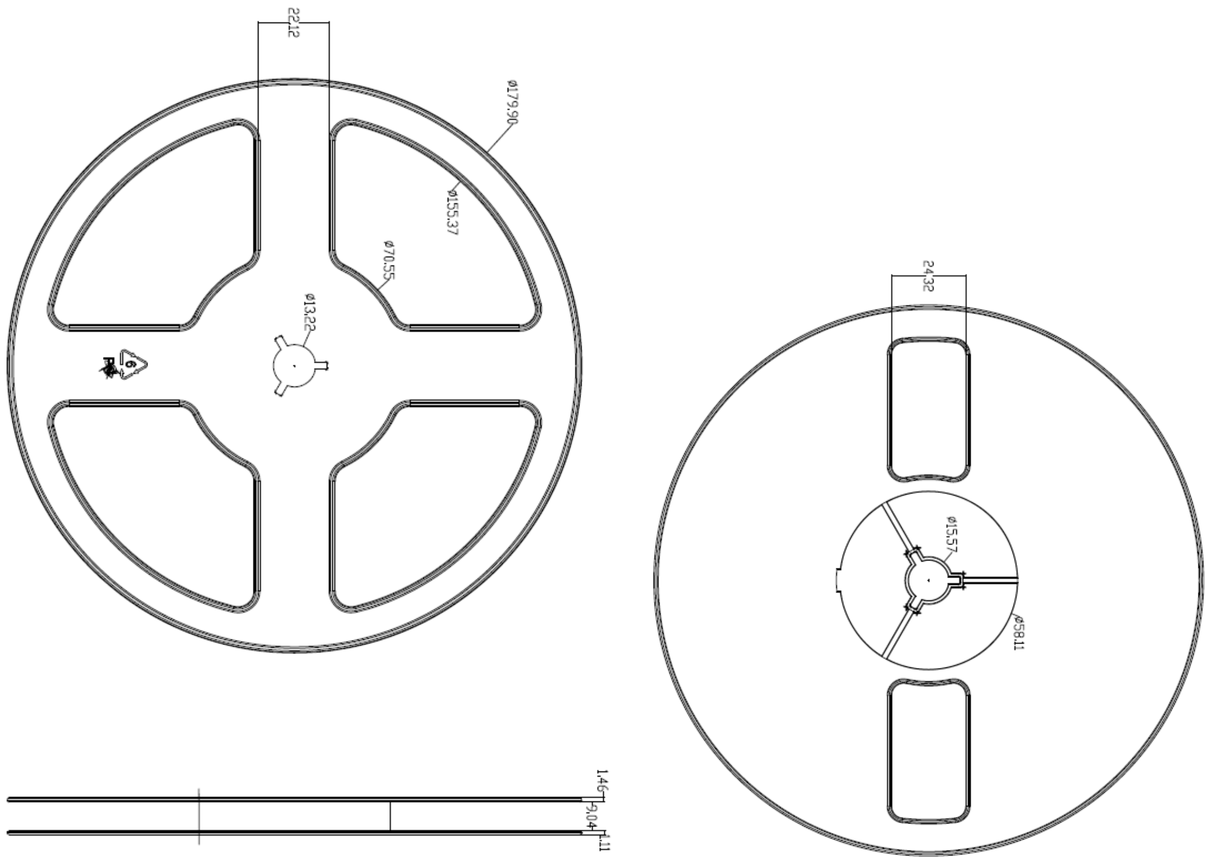


Ao	0.90 +/−0.05
Bo	1.75 +/−0.05
Ko	0.60 +/−0.05
F	3.50 +/−0.05
P1	4.00 +/−0.10
W	8.00 +/−0.20

(I) Measured from centreline of sprocket hole to centreline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III) Measured from centreline of sprocket hole to centreline of pocket.
(IV) Other material available.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

DFN2L Tape Package



DFN2L Reel Package

8.Order Information

Orderable Device	Package Qty	MSL	Device Marking	Description
NST1002-CDNR	3000ea/Reel	1	YXX	DFN-2L package, Tape Reel
NST1002- QTZB	1000ea/Bag	NA	NST102 YWWRXX	TO-92S-2L package, Plastic Bag
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).				

9.Marking

Device	Package	Marking Information		Remark
NST1002-CDNR	DFN-2L	Line1: YXX	YXX	Y: Year XX: Week
NST1002- QTZB	TO-92S-2L	Line1: NST102 Line2: YWWRXX	NST102 YWWRXX	NST102: fixed code Y: Year WW: Week RXX: Wafer version & serial number

10.Revision History

Revision	Description	Date
0.1	Initial Version	2021/05/28
0.2	Add Typical Characteristics. Modify some descriptions.	2022/11/18
0.3	Modify some descriptions. Add Package information	2023/03/16
0.4	Modify some descriptions	2023/03/24
0.5	Add ESD information. Modify some descriptions	2023/04/19
1.0	Add TO-92S-2L Package Information & Marking information	2023/06/14

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