NST1001HA(D-NTC®)

High-Accuracy 2-pins Digital Output Temperature Sensor with Pulse Count

Datasheet (EN) 1.12

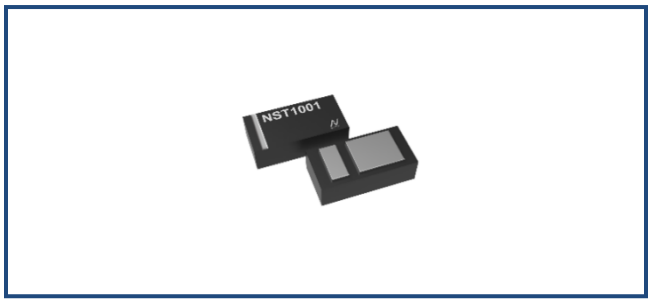
Product Overview

The NST1001HA is a NOVOSENSE D-NTC® series digital temperature sensor, with two pins and unique pulse-counting digital output, which makes it possible to directly connect to the GPIO of the MCU and save MCU resources to the greatest extent. The NST1001HA has a high accuracy and high resolution over temperature range of -50°C to 150°C.

NST1001HA suits automotive, industrial, home appliances and other applications for temperature monitoring, the NST1001HA chip can be easily used as a two-wire digital temperature probe or as a direct replacement for NTC thermistors. The NST1001HA has a built-in EMI filter, which allows it to be used in devices with high interference. The NST1001HA 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.

Key Features

- Operating Temperature Range: -50°C to 150°C
- High Accuracy:
  - 25°C ~ 45°C: ±0.2°C (Max)
  - -20°C ~ 85°C: ±0.5°C (Max)
  - -50°C ~ 150°C: ±0.75°C (Max)
- High Resolution: 0.0625°C
- Fast Temperature Response:
  - Silicone Oil τ63% 0.21s (DFN2L)
- Single Temperature Conversion Time: 50ms
- Supply Voltage Range: 1.65V to 5.5V
- Ultra-low Power Consumption: 30μA Operating Current, Zero Standby Power Consumption
- Pulse Counting Type Digital Output, without ADC interface



Applications

- Digital Output Temperature Probes
- Industrial IoT
- White Goods
- Cold Chain Logistics
- Battery Management
- Body Temperature Detection

Device Information

Part Number	*Package*	*Body Size*
NST1001HA-QDNR	DFN-2L	1.6mm × 0.8mm

Typical Application

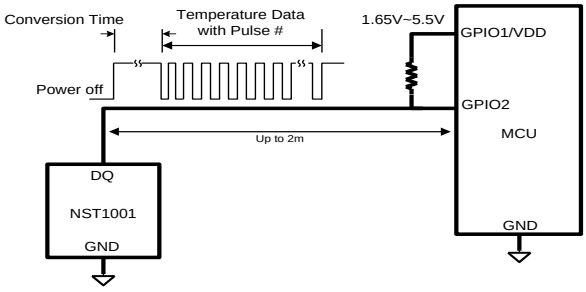


Figure 1 The typical application of NST1001HA

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1 Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit	Comments
DQ Voltage	VDQ	-0.3		6.5	V	
Storage Temperature		-60		155	°C	
Operation Temperature	$TB_{operation}$	-50		150	°C	
Maximum Junction Temperature				155	°C	
ESD Susceptibility	HBM	±8			KV	
	CDM	±1.25			KV	

2 Electrical Characteristics

2.1 Electrical Characteristics

at T_A = +25°C and V_{pu} = +1.65V to +5.5V, unless otherwise noted.

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Supply						
Supply Voltage Range	V_{pu}	1.65	3.3	5.5	V	Pull up resistor 5KΩ
Pull Up Resistor Range	R_{pu}	0.5	5	10	KΩ	
Supply Sensitivity			16		m°C /V	V_{DQ} voltage range from 1.65V to 5.5V
Operation Current Supply Voltage Range	I_{conv}		30	45	μA	Conversion
	I_{com}		1	5	μA	Communication
Temperature Range and Resolution						
Temperature Range		-50		150	°C	
Resolution			0.0625		°C	
Accuracy				±0.2	°C	from 25°C to 45°C
				±0.5	°C	from -20°C to 85°C
				±0.75	°C	from -50°C to 150°C
Pulse count transfer function						
Pulse Count			801			at 0°C
Pulse Count Range		1		3201		
Resolution of One Pulse			0.0625		°C	
High-Level Input Logic	V_H	V_{pu}-0.3			V	
Low-Level Input Logic	V_L			0.2	V	Pull up resistor 5KΩ
Parasitic Cap in DQ Pin	C_{DQ}			$2/R_{pu}$	μF	When R_{pu}=5kohm, C_{DQmax}=400pF

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Reset time when DQ pull down						
Reset Time when DQ pull down	T_{RST}			5	ms	NST1001HA will pull down if DQ pull down more than 5ms
Thermal response						
Stirred oil thermal response time to 63% of final value			0.73		s	TO-92S-2L
			0.21		s	DFN-2L
Still air thermal response time to 63% of final value			4.61		s	TO-92S-2L
			2.94		s	DFN-2L
Drift						
Drift (1)			0.1		°C	

Note: 1. Drift data based on 1000hour stress test at +125°C, VDD = 5.5V.

2.2 Timing Diagram

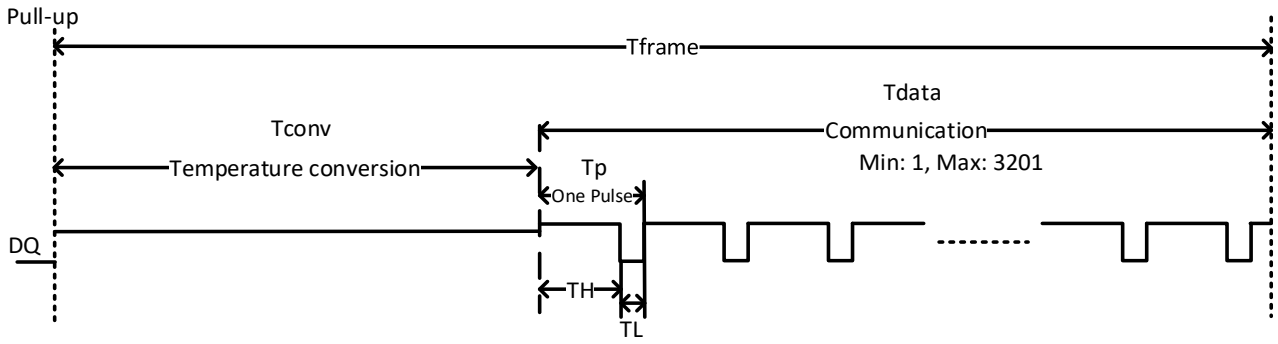


Figure 2.1 Timing Diagram

2.3 Timing Characteristics

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Single Frame Period	T_{frame}	32	50	70	ms	
Conversion Period	T_{CONV}	16	24	35	ms	
Communication Period	T_{data}	16	26	35	ms	
Sigle Pulse Period	T_p	5	8	11	μs	
Sigle Pulse Period Logical High	T_H	4	6	8.3	μs	
Sigle Pulse Period Logical Low	T_L	1.3	2	3	μs	
Digital Output Code		1		3201		
Digital Output Frequency		88	125	189	KHz	

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3 Typical Performance Characteristics

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

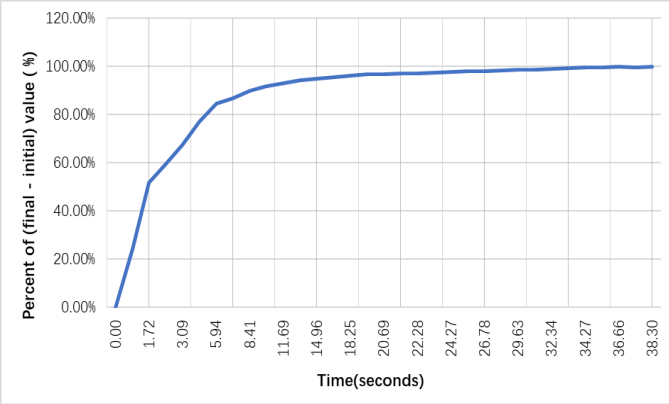


Figure 3.1 Thermal Response in stilling Air (DFN-2L)

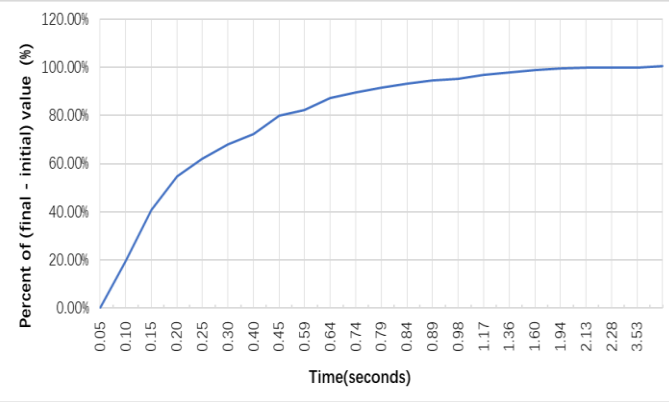


Figure 3.2 Thermal Response in stilling Oil (DFN-2L)

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4 Function Description

4.1 Overview

The NST1001HA is a high-precision digital pulse output temperature sensor, the functional block diagram of which is shown in Figure 4.1. the sensor chip contains an oscillator, temperature ADC, signal conditioning circuit and control interface. the NST1001HA uses a variety of high-precision signal processing techniques to achieve high precision temperature signal processing, avoiding errors caused by process deviations. At the same time, the NST1001HA all contain an OTP, each chip is factory calibrated for temperature, and the calibration coefficients are written into the chip, and the temperature error is calibrated through the digital calibration circuit, thus ensuring its accuracy in the full temperature range. Since the average power consumption of the chip itself is only 15μA, the temperature detection error from the chip self-heating is almost negligible.

The NST1001HA has two pins, DQ and GND, where the power supply and signal output are done through the DQ pin. When in use, the DQ pin is connected to the power supply VDD (or one of the MCU's GPIOs) through a pull-up resistor, and the NST1001HA can obtain power from the pull-up resistor and perform temperature conversion. After a temperature transition, the NST1001HA sends the temperature signal as a pulse through the DQ pin, and the chip's internal circuitry is temporarily powered by an energy storage capacitor. The temperature value is obtained by connecting DQ to one of the MCU GPIOs for simple counting of the pulses, and the NST1001HA is repeatedly converted and sent after power-up, with each temperature conversion plus the external temperature conversion pulses sent for a period of about 50ms.

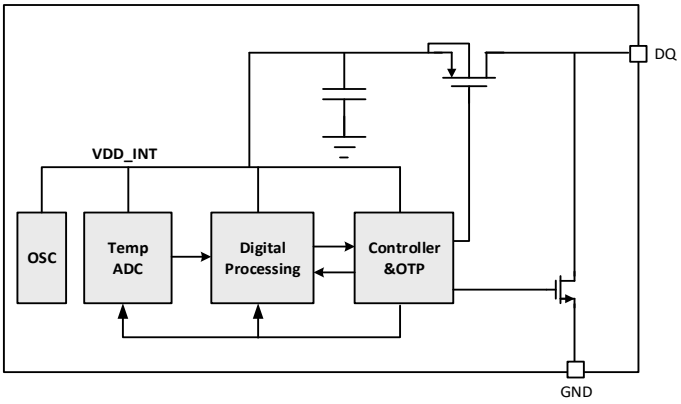


Figure 4.1 NST1001HA Functional Block Diagram

4.2 Feature Description

The NST1001HA represents the temperature value in the form of digital pulse output. Each single pulse cycle takes 50ms, including 24ms for temperature conversion and 26ms for temperature data transmission. The current during the conversion period is 30μA(Typical), and the current during the communication period is 1μA (Typical), a complete single pulse cycle (Single temperature conversion) is shown in Figure 4.2, and a continuous pulse cycle (Multiple temperature conversions) is shown in Figure 4.3.It should be noted that in order to facilitate the MCU to use single temperature conversion mode in some cases, only the first temperature conversion result is read after power on.

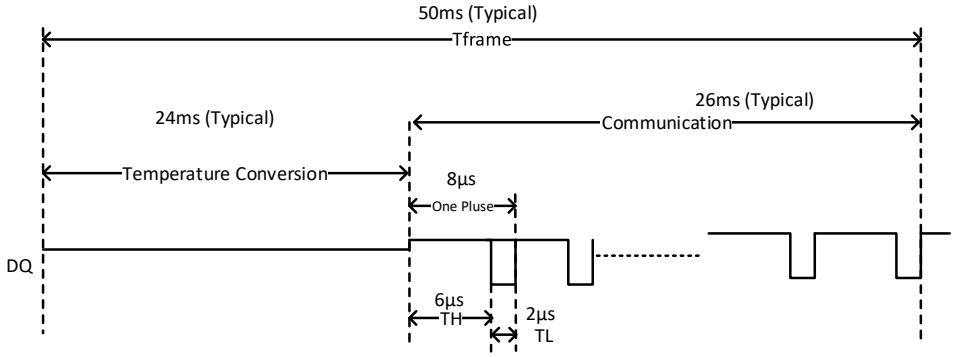


Figure 4.2 Single temperature conversion

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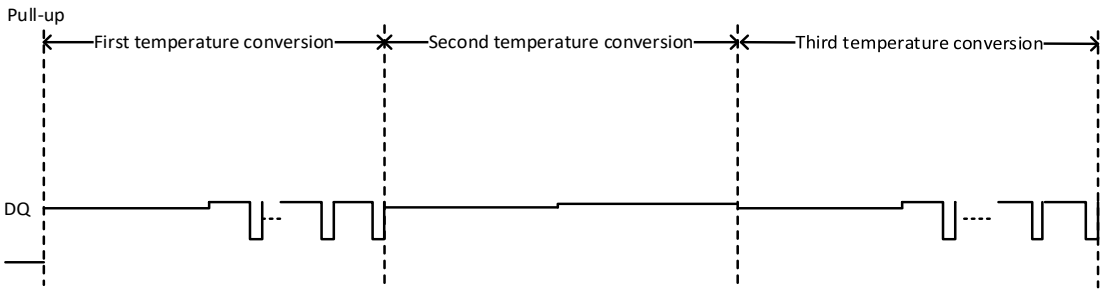


Figure 4.3 Multiple temperature conversions

4.3 Pulse Count and Temperature Conversion Equation

The NST1001HA outputs at minimum 1 pulse and a theoretical maximum 3201 pulses. Each pulse has a weight of 0.0625°C. Therefore, one pulse corresponds to a temperature less than –50°C while a pulse count of 3201 corresponds to a temperature greater than 150°C. Note that the NST1001HA is only ensured to operate up to 150°C. Exceeding this temperature by may damage the device. The output transfer function appears to be linear and can be approximated by Equation 4-1:

$$\mathrm{Temp} = \mathrm{Num} \times 0.0625℃ - 50.0625℃ \tag{4-1}$$

where

Temp is the temperature reading.

Num represents pulse count (1 ~ 3201).

The partial temperature values calculated according to the pulse number temperature conversion equation and the corresponding pulse number are shown in table 4.1.

Table 4.1 Temperature corresponds to the number of pulses

Temperature (℃)	*Number of pulses*
-50	1
-40	161
-20	481
0	801
30	1281
50	1601
100	2401
150	3201

In order to obtain to better temperature accuracy and eliminate the non-linear temperature difference between high and low temperatures, a segmented temperature calculation formula is given, as shown in Equation 4-2:

$$\begin{cases} \mathrm{T} = \mathrm{Temp} + (\mathrm{Temp} - 30) \times 0.005 & \mathrm{Temp} < 30℃ \\ \mathrm{T} = \mathrm{Temp} & 30℃ \le \mathrm{Temp} \le 100℃ \\ \mathrm{T} = \mathrm{Temp} + (100 - \mathrm{Temp}) \times 0.012 & 100℃ < \mathrm{Temp} < 150℃ \end{cases} \tag{4-2}$$

Where the Temp is the initial temperature which come from Equation 4-1. Better temperature accuracy as shown in Figure 3.2 can be obtained using Equation 4-2.

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5 Typical Application

The NST1001HA uses a parasitic power supply mode, which means that it uses the high time charge of the communication pin DQ to complete its work. The chip uses a two-pin connection, DQ as the communication digital pulse output and parasitic power supply, and GND to ground. The GPIO port of the microcontroller is connected to the DQ terminal of the chip to count the pulses output after each temperature conversion, and then convert the number of pulses to temperature.

5.1 Single GPIO Application

DQ pin is connected to a GPIO and connected to VDD through a pull-up resistor, as shown in Figure 5.1. The NST1001HA is powered by a pull-up resistor and the number of pulses is counted through GPIO when pulses are output. This application method requires only one GPIO port, which saves the GPIO resources of the microcontroller. When a power-down reset of the NST1001HA is required, it only needs to be pulled down via GPIO for more than 5ms.

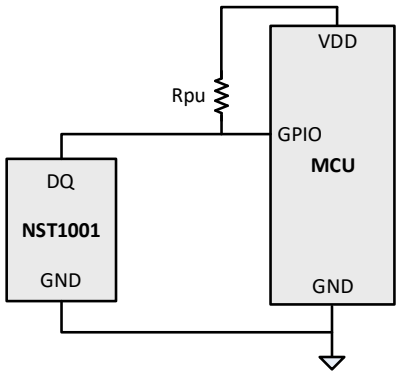


Figure 5.1 Sigle GPIO application

Table 5.1 Design parameter

Design parameter	*Value*
R_{pu}	0.5KΩ~10KΩ
VDD	1.65V~5.5V
Microcontroller	Interrupt resource

Note: The maximum operating current for chip operation is 30μA (Typical), the choice of pull-up resistor Rpu will affect the minimum operating voltage allowed for VDD, here according to R_{pu}=5KΩ, the minimum operating voltage for VDD is obtained as 1.65V.

5.2 No Power Consumption in Standby Mode Application

DQ is connected to GPIO2 and GPIO1 of MCU through a pull-up resistor, as shown in Figure5.2. GPIO1 is pulled high to supply power to the chip through the pull-up resistor. When the pulse is output, GPIO2 is set as input IO to count the pulse and convert it to get the temperature. After conversion, GPIO1 is pulled low to stop powering the chip and the NST1001HA does not consume any standby power.

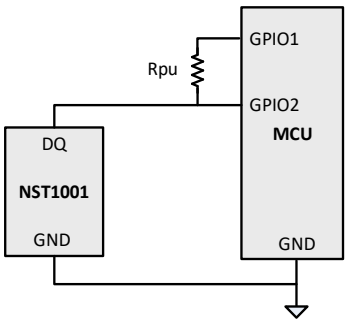


Figure 5.2 No power consumption in standby mode application

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5.3 Pull-down Resistor Design Solutions

Figure5.3 shows the typical application connection diagram of the pull-down resistor connection of NST1001HA, similar to the common NTC temperature acquisition scheme. Using this scheme, it can directly replace the traditional NTC temperature acquisition scheme without changing any peripheral circuit design.

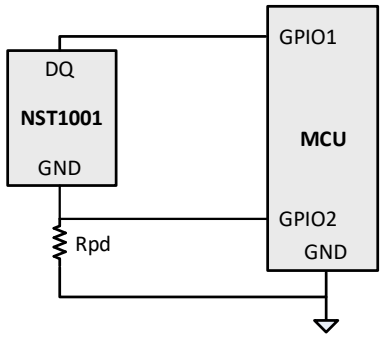


Figure 5.3 Pull down resistor application

5.4 Multi-point Temperature Acquisition

As shown in Figure5.4, all NST1001HA 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.

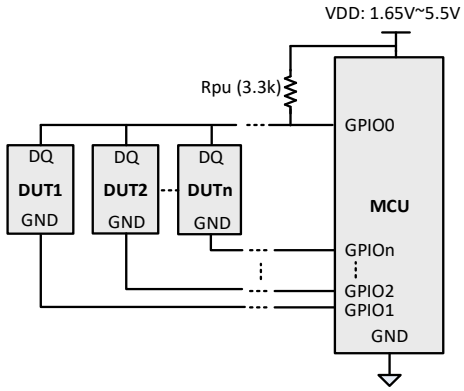


Figure 5.4 Multi-point temperature acquisition with NST1001HA

5.5 Temperature Isolated Acquisition

As shown in Figure 5.5, this solution utilizes NOVOSNS' digital isolation chip NSi8121 used together for applications that require isolation for temperature acquisition.

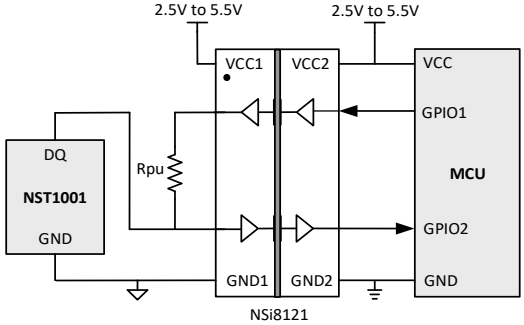


Figure 5.5 Isolation application schematic

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6 Package Information

6.1 DFN-2L Package

6.1.1 Package Information

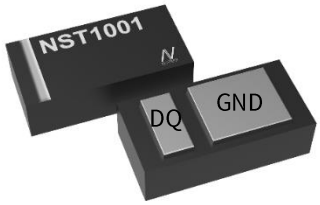
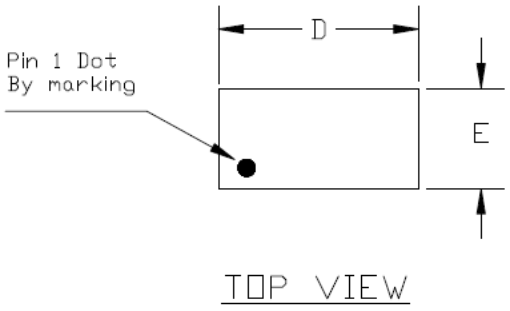
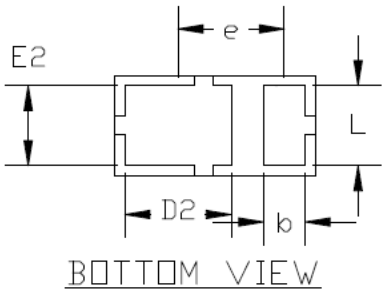


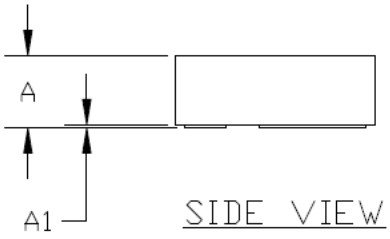
Figure 6.1 NST1001HAHA DFN-2L package

Table 6.1 NST1001HA Pin Configuration and Description

NST1001HA PIN NO.	*SYMBOL*	*FUNCTION*
1	DQ	Supply and digital IO
2	GND	GND





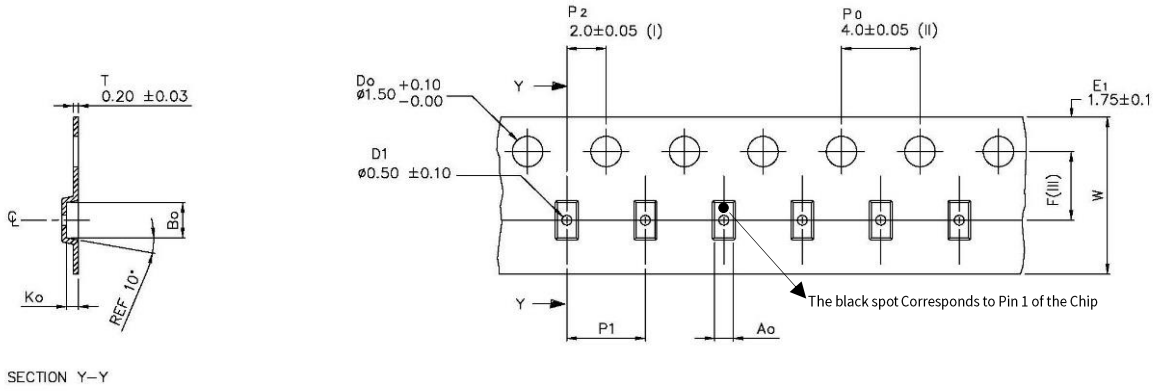


COMMON DIMENSIONS(MM)			
PKG.	X1: EXTREME THIN		
REF.	MIN.	NOM.	MAX
A	0.40	0.45	0.50
A1	0.00	–	0.05
A3	0.125 REF.		
D	1.55	1.60	1.65
E	0.75	0.80	0.85
D2	0.75	0.85	0.95
E2	0.54	0.64	0.74
L	0.54	0.64	0.74
b	0.28	0.33	0.41
e	0.85 BSC		

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6.1.2 Tape and Reel Information

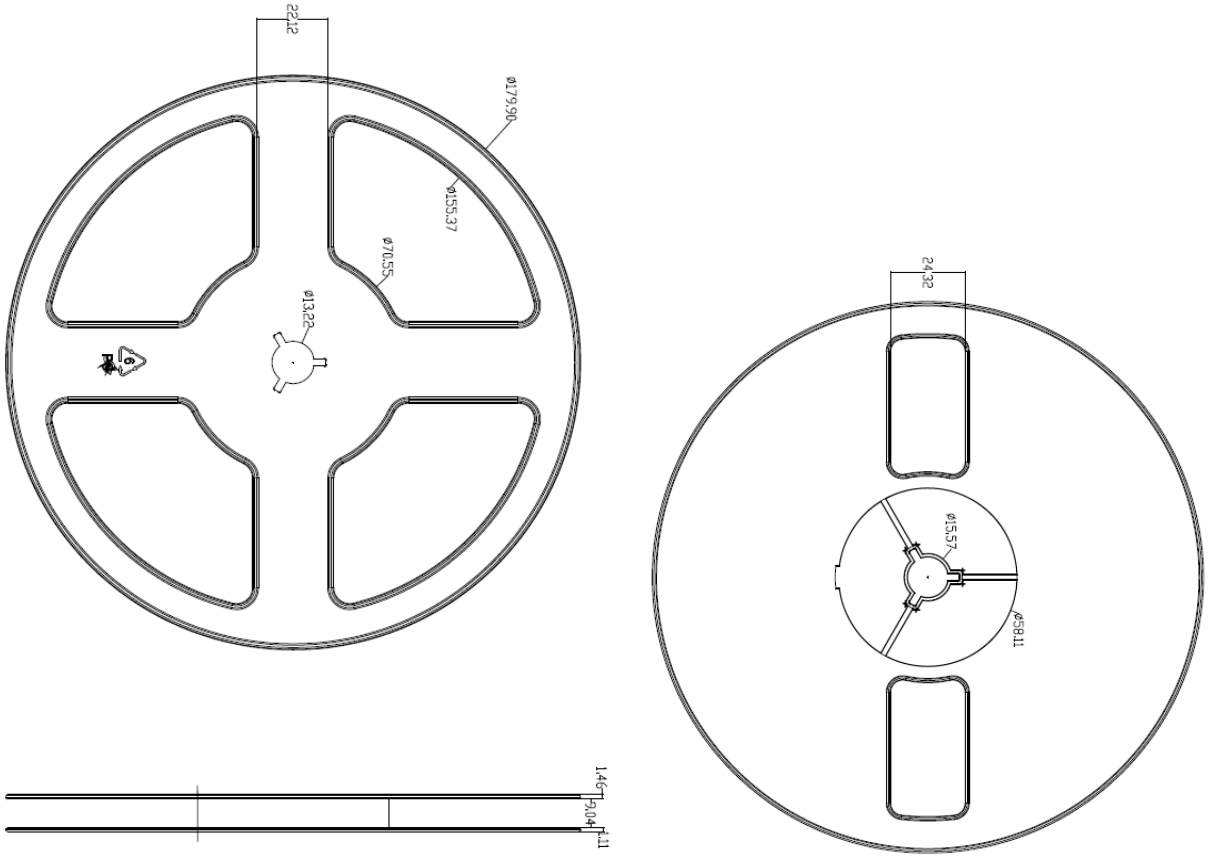


Ao	0.90 +/−0.05
Bo	1.75 +/−0.05
Ko	0.60 +/−0.05
F	3.50 +/−0.05
P1	4.00 +/−0.10
W	8.00 +/−0.20

(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 Package Tape Specifications



DFN2L Package Reel Specifications

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7 Ordering Information

Order Model	Package form	MSL	laser mark information	Description
NST1001HA-QDNR	3000ea/Reel	1	XXY	DFN-2L, Tape 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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8 Revision History

Revision	Description	Date
0.0	Initial Version	2018/6/7
0.1	Initial release version	2018/9/10
1.0	Mass production version	2018/12/17
1.1	Add temperature error correction formula	2019/01/11
1.2	Revise the format	2019/6/19
1.3	Revised packaging format and added silk screen content	2019/10/11
1.4	Modified the order material number in the order information	2019/11/28
1.5	Added order material number	2020/2/10
1.6	Revised TO-92S air response time parameter, modified other text descriptions	2020/5/13
1.7	Modified order information; modified chip silkscreen schematic; modified some timing parameters; added TAPE&REEL information; modified some text descriptions on home page	2020/11/26
1.8	Modified test data	2021/01/21
1.9	Delete NST1001HA related information; modify part of the text description	2022/03/01
1.10	Modified device information. Improved text description. Modified ordering information. Revise Package Information. Add important notice.	2022/08/26
1.11	Modified order information	2022/09/14
1.12	Modify some descriptions.	2023/10/30

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