# Analog Temperature Sensor with Class AB Output

## 1 Features

- GXT84/85/86/87 are a series of analog temperature sensors with negative temperature coefficients and average sensor gains of -5.5 mV/°C, -8.2 mV/°C, -10.9 mV/°C, -13.6 mV /°C.
- Temperature range: **- 55°C ~ + 1 25 °C, up to +140°C**
- Temperature accuracy: **± 0.4°C (typ.)**
- The output is short-circuit protected
- Power supply voltage: **2.5V ~ 5.5 V**
- Low quiescent current: **less than 10μA**
- Analog temperature sensors compatible with LM20/19 and LM35 package

## 2 Applications

- Thermal management system
- Temperature control
- Home appliances

图1 5-pin-SOT
（SC70）

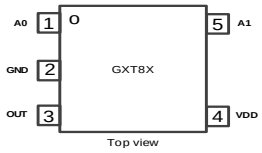



图2 TO-92

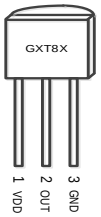
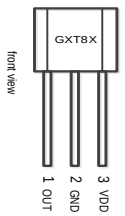



图3 TO-92S




## 3 Description

GXT84/85/86/87 are a series of analog temperature sensors with negative temperature coefficients that provide an analog voltage output which is linearly proportional to the Celsius temperature. The GXT8X performs factory calibration, so no external calibration is required, with a typical accuracy of ±4°C at +25°C and a maximum accuracy of ±2.7°C in the temperature range from 40°C to + 125°C.

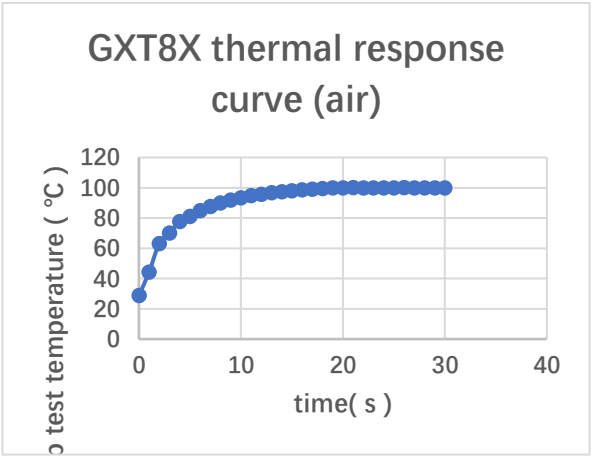
GXT84/85/86/87 (the GXT8X series only include these four models) feature low-output impedance, linear output, and factory calibration, enabling significant simplification of temperature control circuits and ADC requirements. This series of sensor components can operate with a single power supply ranging from 1.5V to 5.5V. The power supply current is below 10μA, and the self-heating effect is minimal, with a temperature change of less than 0.1°C in static air.

GXT84/85/86/87 are available in low-cost 5-pin SOT353 surface mount, 3-pin TO-92 and 3-pin TO92S packages.

**Chip Package Information**

| Product Number | Packaging Information | Body Size (NOM) |
|---|---|---|
| GXT8XG | SOT353 (5) | 2.10mm*1.25mm |
| GXT8XS | TO-92S(3) | 4.0mm 3.0mm |
| GXT8X | TO-92(3) | 4.6mm*4.6mm |

* Where X can represent 4, 5, 6, 7.



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## 4 Pin Configuration and Functions

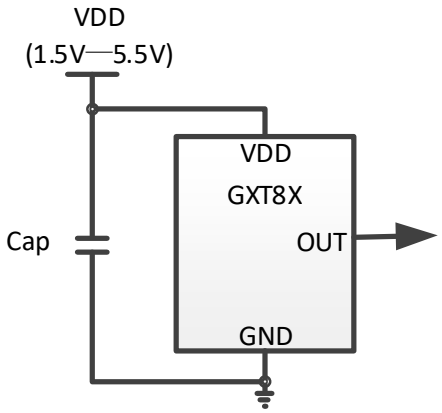



Figure 4 Typical Application

Table 1 Chip Pin Description

| Pin name | Pin name | | | Illustration |
|---|---|---|---|---|
| | SOT (SC70) | TO-92 | TO-92S | |
| A0 | 1 | / | / | Chip enable pin 0 |
| GND | 2 | 3 | 2 | Ground |
| OUT | 3 | 2 | 1 | Analog voltage output |
| VDD | 4 | 1 | 3 | Chip power supply port |
| A1 | 5 | / | / | Chip enable pin 1 |

Table 2 Description of GXT84/85/86/87 SOT (SC70) Package and Connections of Pin A0 and A1

| Pin name | Chip Model and Corresponding Connection Method | | | |
|---|---|---|---|---|
| | GXT84 | GXT85 | GXT86 | GXT87 |
| A0 | GND | VDD | GND | VDD |
| A1 | GND | GND | VDD | VDD |

# 5 Specifications

## 5.1 Absolute Maximum Ratings

| | MIN | MAX | UNIT |
|---|---|---|---|
| **Power Supply Voltage** +Vs | | 6 | V |
| **OUT Pin** | GND | VDD+0.4 | V |
| **Junction Temperature** | | 1 50 | °C |
| **Storage Temperature** | - 60 | 1 50 | °C |

Unless otherwise noted, the specifications in the above table apply within the atmospheric temperature range. Stresses beyond the range may cause permanent damage to the device.

## 5.2 Electrostatic Protection

| | | Value | UNIT |
|---|---|---|---|
| **Electrostatic Discharge Voltage $V_{ESD}$** | Human Body Mode (HBM), per ANSI/ESDA/JEDEC JS-001 | ±4000 | V |
| | Machine Mode (MM), per JEDEC-STD Classification | ±200 | V |

## 5.3 Recommended Operating Conditions

| | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|
| **Supply Voltage (VDD) GXT84** | 1.5 | 3.3 | 5.5 | V |
| **Supply Voltage (VDD) GXT85** | 1.8 | 3.3 | 5.5 | V |
| **Supply Voltage (VDD) GXT86** | 2.2 | 3.3 | 5.5 | V |
| **Supply Voltage (VDD) GXT87** | 2.7 | 3.3 | 5.5 | V |
| **GXT8X Operating Temperature Range ($TA_)$** | - 50 | | 140 | °C |

Unless otherwise noted, the specifications in the above table apply within the atmospheric temperature range.

## 5.4 Electrical Characteristics

Unless otherwise specified, the following data refer to the characteristics of the chips at +25°C and the power supply voltage is within the corresponding maximum and minimum operating voltage range of each chip. (Typical working conditions are at +25°C and 3.3V.)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| **Supply Voltage Range** | GXT84 | 1.5 | | 5.5 | V |
| | GXT85 | 1.8 | | 5.5 | V |
| | GXT86 | 2.2 | | 5.5 | V |
| | GXT87 | 2.7 | | 5.5 | V |
| **Supply Current** | Normal Operation (VDD-OUT>200mV) | | 5.6 | 9.3 | uA |
| **Temperature Range** | GXT8X | -50 | | 140 | °C |
| **GXT8X Accuracy (temperature error)** | +25°C, +Vs = 3.3V | | ±0.4 | | °C |
| | -55°C to +140°C, +VS = 3.3V | | ±1 | ±2.7 | °C |
| **Supply Voltage Sensitivity** | $T_A$=25°C, 3.0V<+Vs<5.5V | | 20 | 100 | m°C/V |
| **Scale Factor** | GXT84 | | -5.5 | | mV/°C |
| | GXT85 | | -8.2 | | mV/°C |
| | GXT86 | | -10.9 | | mV/°C |
| | GXT87 | | -13.6 | | mV/°C |
| **Voltage Linear Regulation Rate** | GXT8X | | 200 | | μ V/V |
| **Output Load Current** | | -50 | | 50 | uA |
| **Capacitive Load Drive** | | | 1000 | | pF |
| **Device Turn-on Time** | $C_L$=0pF-1nF | | 0.7 | 2 | ms |

## 6 Typical Characteristics

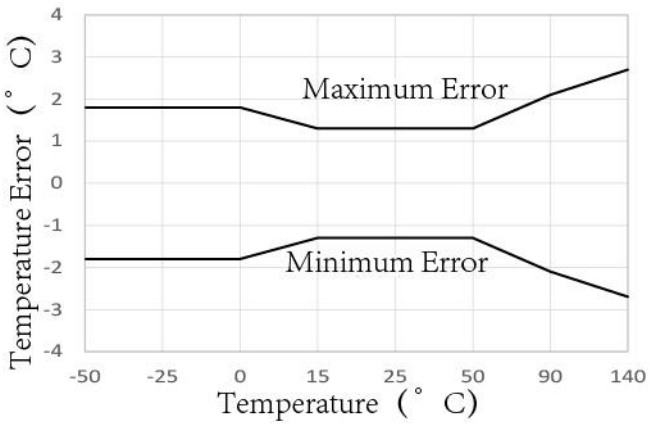



Figure 5 Temperature Error vs Temperature

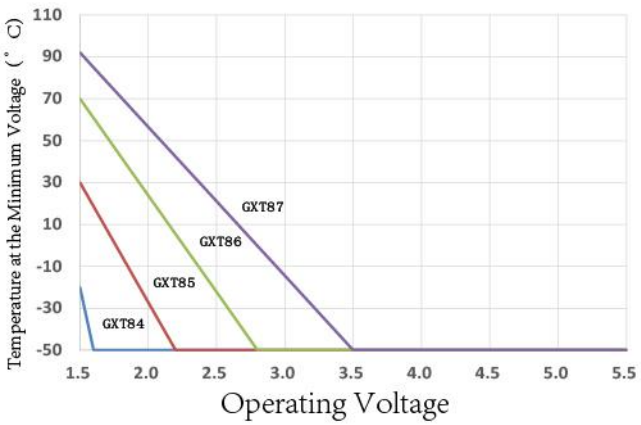



Figure 6 Operating Temperature vs Minimum Operating Voltage

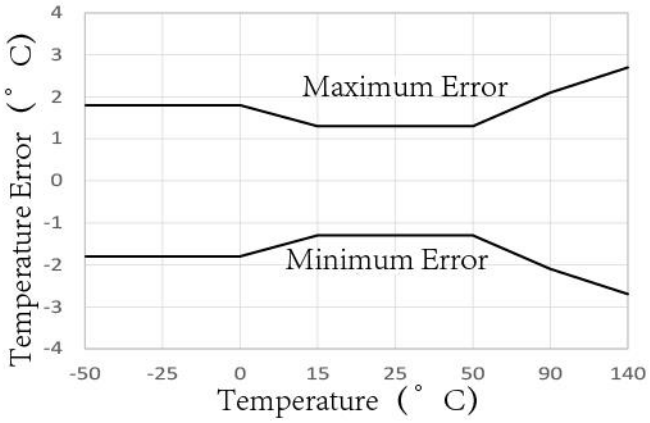



Figure 7 Operating Current vs Operating Temperature

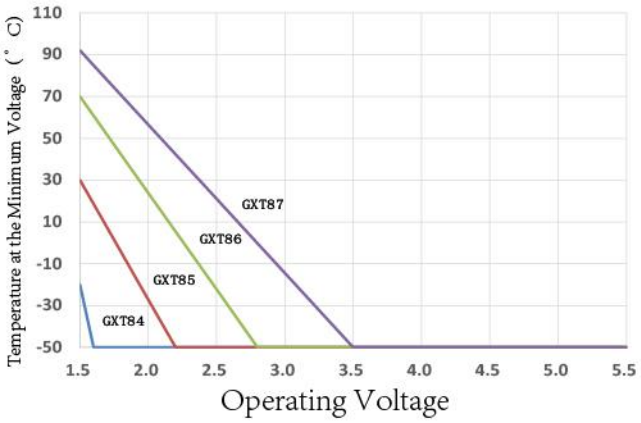



Figure 8 Operating Current vs Operating Voltage

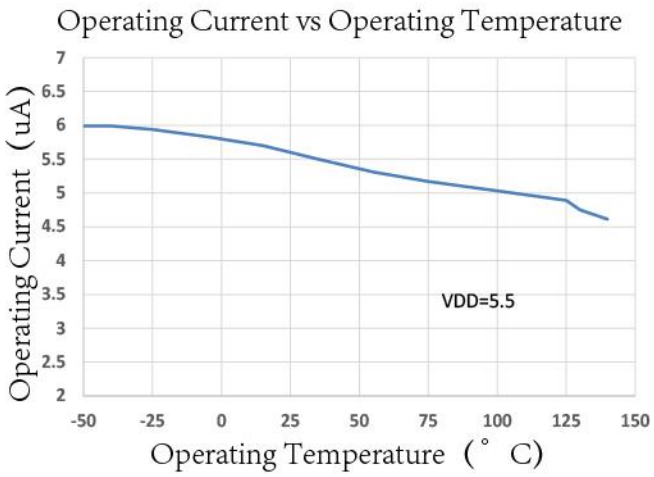



Figure 9 Current Load Adjustment

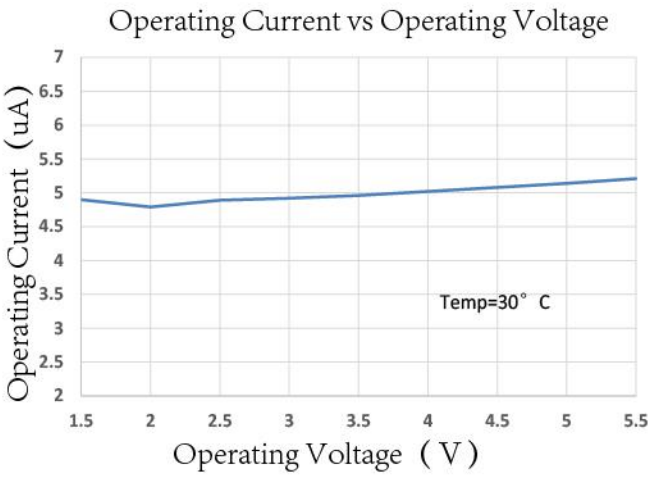



Figure 10 Sample test

# 7 Detailed Description

**NOTE**

The above contents are the precautions for GXT8X recommended by Beijing Galaxy-CAS Technology Co., Ltd. in practical applications. Customers are responsible for determining suitability of components for their purposes based on their own usage needs and application scenarios. Customers should test and verify their design implementation to confirm system functionality and avoid losses.

## 7.1 Overview

GXT8X includes a series of analog output temperature sensors. The temperature-sensing element of the sensor consists of a forward current biased PN junction connected to a push-pull output low-impedance op-amp serving as the BUFFER of the OUT port.

## 7.2 Functional Block Diagram

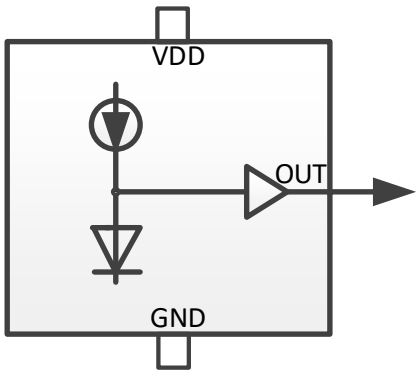



Figure 11 Internal Framework Diagram

## 7.3 Transfer Function

Table 3 shows the corresponding output voltage values of the GXT8 X series products at different temperatures. The data can be used in a look-up table.

Table 3 Relation Between GXT8X Temperature and Output Voltage

| Ambient Temperature (° C) | VOUT Output Voltage (mV) | | | |
|---|---|---|---|---|
| | GXT84 | GXT85 | GXT86 | GXT87 |
| -50 | 1299 | 1955 | 2616 | 3277 |
| -40 | 1247 | 1885 | 2522 | 3160 |
| -30 | 1194 | 1806 | 2418 | 3030 |
| -20 | 1141 | 1727 | 2313 | 2899 |

| | | | | |
|---|---|---|---|---|
| -10 | 1088 | 1648 | 2207 | 2767 |
| 0 | 1034 | 1567 | 2100 | 2633 |
| 10 | 980 | 1486 | 1993 | 2500 |
| 20 | 925 | 1405 | 1885 | 2365 |
| 30 | 871 | 1324 | 1777 | 2231 |
| 40 | 816 | 1242 | 1668 | 2095 |
| 50 | 760 | 1159 | 1558 | 1958 |
| 60 | 704 | 1076 | 1448 | 1819 |
| 70 | 647 | 991 | 1335 | 1679 |
| 80 | 591 | 907 | 1223 | 1539 |
| 90 | 534 | 822 | 1110 | 1399 |
| 100 | 476 | 737 | 997 | 1257 |
| 110 | 419 | 651 | 883 | 1115 |
| 120 | 361 | 565 | 769 | 973 |
| 130 | 302 | 478 | 653 | 829 |
| 140 | 243 | 390 | 537 | 684 |
| | | | | |

Although the output curve of the GXT8X series sensor is relatively linear which can be seen from Table 3. The output voltage of the sensor can be approximately expressed by the following equation:

**The temperature of the GXT84 is calculated by the following approximate formula:**

$$V_{OUT} = 870.6mV - \left[5.506\frac{mV}{^\circ C}\left(T - 30\ ^\circ C\right)\right] - 0.00176\frac{mV}{^\circ C^2}\left(T - 30\ ^\circ C\right)^2 \quad (1)$$

$$T_{84} = \frac{5.506 - \sqrt{(-5.506)^2 + 4\times 0.00176\times (870.6 - V_{OUT}(mV))}}{2\times(-0.00176)} + 30 \quad (2)$$

If the temperature range is not wide (for example, 0-50° C), the temperature can also be calculated using the following equivalent formula:

$$T_{84} = \frac{V_{OUT}(mV) - 1035V}{-5.5mV/^\circ C} \quad (3)$$

**The temperature of the GXT85 is calculated by the following approximate formula:**

$$V_{OUT} = 1324.0mV - \left[8.194\frac{mV}{^\circ C}(T - 30^\circ C)\right] - 0.00262\frac{mV}{^\circ C^2}(T - 30^\circ C)^2 \quad (4)$$

$$T_{85} = \frac{8.194 - \sqrt{(-8.194)^2 + 4\times 0.00262\times (1324 - V_{OUT}(mV))}}{2\times(-0.00262)} + 30 \quad (5)$$

If the temperature range is not wide (for example, 0-50° C), the temperature can also be calculated using the following equivalent formula:

$$T_{85} = \frac{V_{OUT}(mV) - 1569mV}{-8.2mV/^\circ C} \quad (6)$$

**The temperature of the GXT86 is calculated by the following approximate formula:**

$$V_{OUT} = 1777.3mV - \left[10.888\frac{mV}{^\circ C}(T - 30^\circ C)\right] - 0.00347\frac{mV}{^\circ C^2}(T - 30^\circ C)^2 \quad (7)$$

$$T_{86} = \frac{10.888 - \sqrt{(-10.888)^2 + 4\times 0.00347\times (1777.3 - V_{OUT}(mV))}}{2\times(-0.00347)} + 30 \quad (8)$$

If the temperature range is not wide (for example, 0-50° C), the temperature can also be calculated using the following equivalent formula:

$$T_{86} = \frac{V_{OUT}(mV) - 2103mV}{-10.9mV/^\circ C} \quad (9)$$

**The temperature of the GXT84 is calculated by the following approximate formula:**

$$V_{OUT} = 2230.8mV - \left[13.582\frac{mV}{^\circ C}(T - 30^\circ C)\right] - 0.00433\frac{mV}{^\circ C^2}(T - 30^\circ C)^2 \quad (10)$$

$$T_{87} = \frac{13.582 - \sqrt{(-13.582)^2 + 4\times 0.00433\times (2230.8 - V_{OUT}(mV))}}{2\times(-0.00433)} + 30 \quad (11)$$

If the temperature range is not wide (for example, 0-50° C), the temperature can also be calculated using the following equivalent formula:

$$T_{87} = \frac{V_{OUT}(mV) - 2637mV}{-13.6mV/^\circ C} \quad (12)$$

## 7.4 Thermal Conductivity and Installation Precautions

To ensure good thermal conductivity of the GXT8X sensor, the back of the die can be directly connected to the GND pin. The temperature of the solder pads and trace of other leads (pins) of the GXT8X will also affect the temperature reading. According to customer's application requirements, the GXT8X can be made into a sealed metal probe for measuring the temperature of liquids. Like other IC applications, the GXT8X and its associated wiring and circuit must be kept insulated and dry to prevent leakage and corrosion. Some protective measures need to be taken in this application scenario to prevent pin short circuits or damage that could cause malfunction of the GXT8X.

The chip self-heating calculation formula is as follows:

$T_J = T_A + \emptyset_{JA}[V_{DD} \times I_D + (V_{DD} - V_{OUT}) \times I_L]$

$T_J$ is the chip temperature after the chip self-heats;

$T_A$ is the ambient temperature;

$\emptyset_{JA}$ is the thermal resistance;

$V_{DD}$ is the supply voltage;

$I_D$ is the chip power consumption;

$V_{OUT}$ is the chip output voltage;

$I_L$ is the output voltage on the output pin;

For example, for SOT(5), in an application where $T_A = 30^\circ C$, $\emptyset_{JA} = 300^\circ \frac{C}{W}$, $V_{DD} = 5V$, $I_D = 5.4uA, V_{OUT} = 1.7V, I_L = 0\ uA$, the junction temperature would be $T_J$= 30.008°C, indicating a self-heating error of only 0.015° C.

## 7. 5 Filtering and Low-power Applications

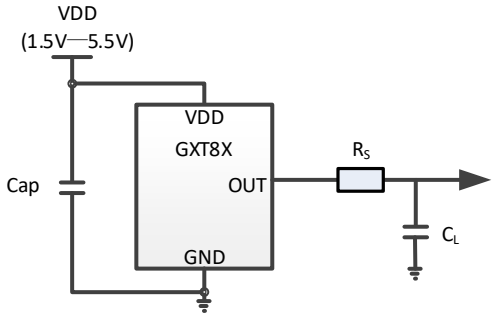



Figure 12 GXT8X with Filter Capacitor Application

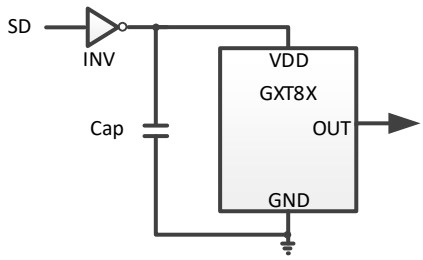



Figure 13 GXT8X Low-power Application

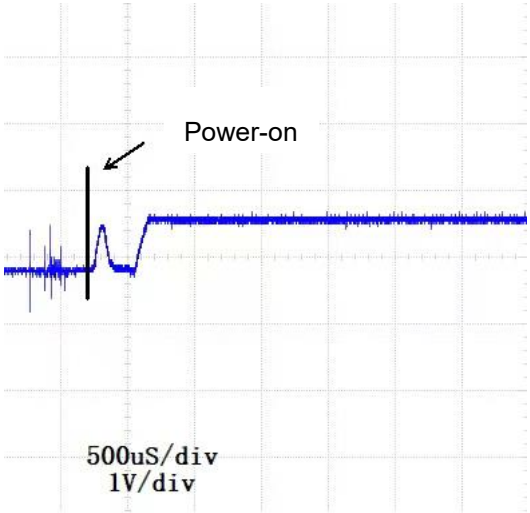


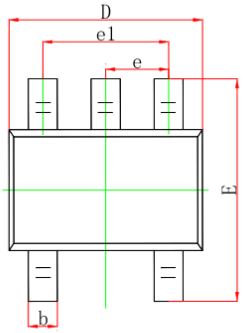

Figure 14 GXT8X Startup Response Diagram

Table 4. Recommended Values for Peripheral Circuits

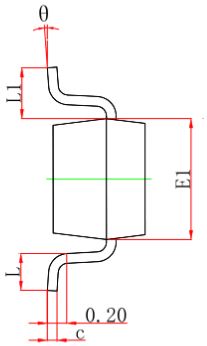
| $C_L$ | Minimum Resistance $R_S$ | Cap |
|---|---|---|
| <1.1nF | 0kΩ | 0.1uF |
| 1.1nF—99nF | 3kΩ | 0.1uF |
| 100nF —999nF | 1.5kΩ | 0.1uF |
| >1uF | 800Ω | 0.1uF |

## 8 Package Information

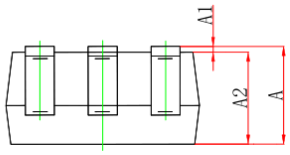
1) GXT8XG SOT353(SC70)




TOP VIEW
[顶视图]



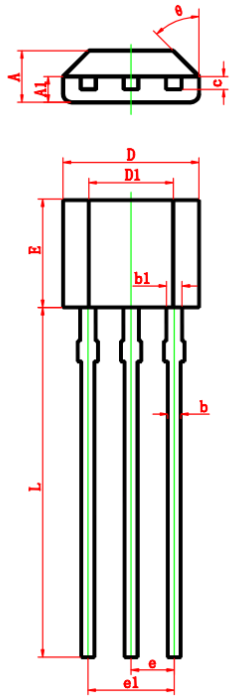

SIDE VIEW
[侧视图]




SIDE VIEW
[侧视图]

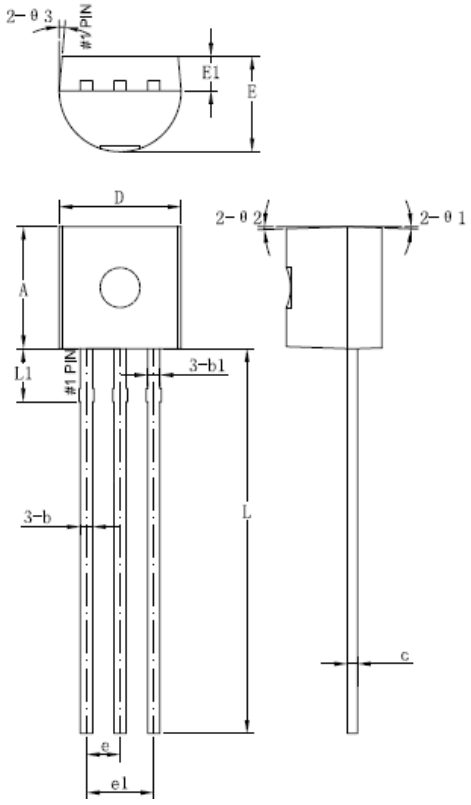
| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min. | Max. | Min. | Max. |
| A | 0.900 | 1.100 | 0.035 | 0.043 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 0.900 | 1.000 | 0.035 | 0.039 |
| b | 0.150 | 0.350 | 0.006 | 0.014 |
| c | 0.110 | 0.175 | 0.004 | 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° |

2）GXT8XS TO-92S




| 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 |
| θ | 45° TYP. | | 45° TYP. | |

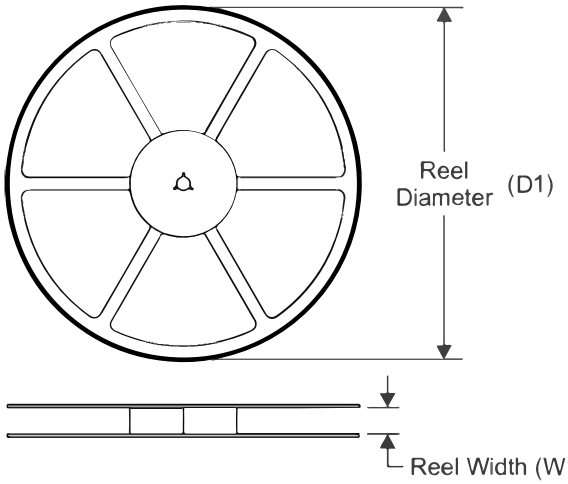
3) GXT8X TO-92



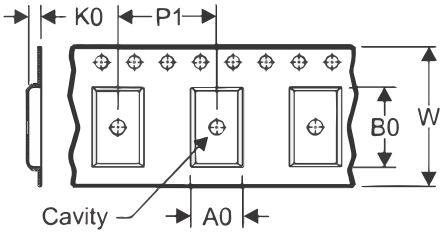

| 符号 | 机械尺寸/mm | | |
|---|---|---|---|
| | 最小值 | 典型值 | 最大值 |
| A | 4,5 | 4,6 | 4,7 |
| b | 0.38 | 0.46 | 0.56 |
| b1 | | 0.46 | |
| c | 0.36 | 0.38 | 0.51 |
| D | 4,5 | 4,6 | 4,7 |
| E | 3,45 | 3.6 | 3.75 |
| E1 | 1.2 | 1,3 | 1,4 |
| e | | 1,27 | |
| e1 | | 2,54 | |
| L | 13.5 | 14.5 | 15,3 |
| L1 | | 1,96 | |
| θ1 | | 2° | |
| θ2 | | 2° | |
| θ3 | | 5° | |

5) Tape and Reel

REEL DIMENSIONS

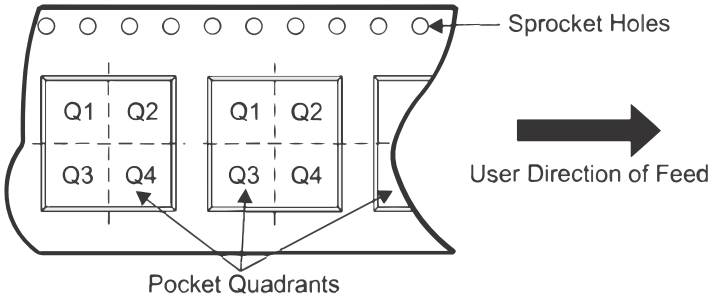



TAPE DIMENSIONS




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE




| Packaging Form | D1 (mm) | W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|
| SOT353 (SC70) | 178 | 9.5 | 2.3 | 2.55 | 1.2 | 4.00 | 8.00 | Q1 |

## 9 Ordering Information

| Purchasing Code | Devices | Packaging | SPQ | Note |
|---|---|---|---|---|
| GXT8XG-T&R | GXT8XG | SOT353(SC70) | 3000 | Tape and Reel |
| GXT8X-Bu | GXT8X | TO92 | 2000 | Bagged |
| GXT8XS -Bu | GXT8XS | TO92S | 2000 | Bagged |

Note: When purchasing GXT84, the second X in the purchase code is 4;
When purchasing GXT85, the second X in the purchase code is 5;
When purchasing GXT86, the second X in the purchase code is 6;
When purchasing GXT87, the second X in the purchase code is 7.

Revision History：

| Version | Date | Description | Modified pages | Illustration |
|---|---|---|---|---|
| V1.1 | 10/31 | The original version | - | |
| V1.2 | 2024.01.29 | Changed the ordering information | 12 | |
| V1.3 | 2024.08.20 | Correct the calculation formula | 8，9 | |
| V1.4 | 2024.10.12 | Correct the package name | 1，11，14 | |