Analog Temperature Sensor with Class AB Output

1 Features

- The GD30TS084T 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 to + 125 °C, up to +140°C
- Temperature accuracy: ±0.4°C (typical)
- The output is short-circuit protected
- Power supply voltage: 2.5V to 5.5 V
- Low quiescent current: less than 10μA

2 Applications

- Portable and battery-powered applications
- Thermal management system
- Temperature control
- Home appliances

3 Description

The GD30TS084T 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 GD30TS08XT 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.

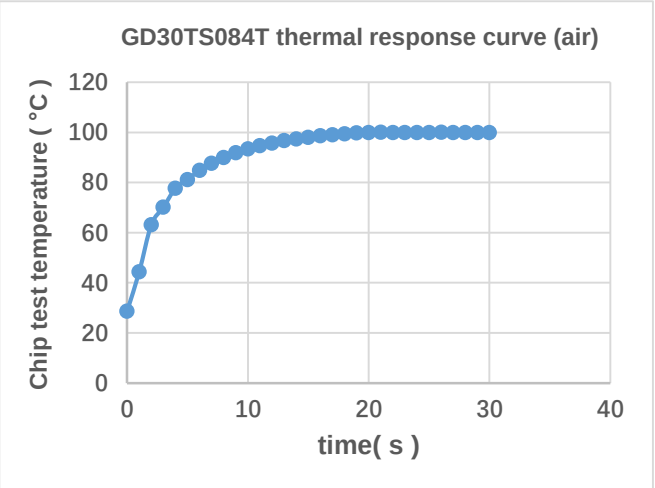
The GD30TS084T (the GD30TS08XT series only include these four models)feature low-output impedance, linear output, and factory calibration, enabling significant simplification of temperature control circuits and ADC requirements. This series of sensor components can operate with a single power supply 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.

The GD30TS084T are available in low-cost 5-pin SC70 surface mount, 3-pin TO-92 and 8-pin SOIC and three packages.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
GD30TS08X	SC70	2.10mm x 1.25mm
	TO-92	4.60mm x 4.60mm
	TO- 92S	4.00mm x 3.15mm

1. For packaging details, see *Package Information* section.
2. Where X can represent 4, 5, 6, 7.



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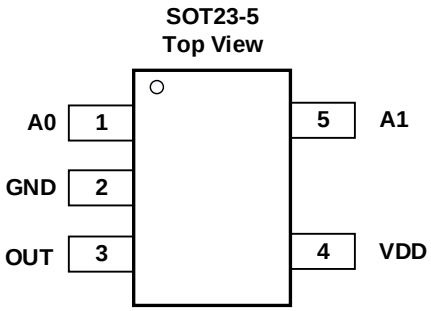
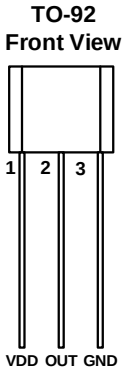
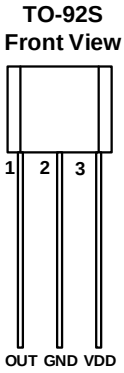
4.1 Pinout and Pin Assignment







4.2 Pin Description

PINS				PIN TYPE[1]	FUNCTION
NAME	SC70	TO-92	TO-92S		
A0	1			I	Chip enable pin 0.
GND	2	3	2	G	Ground.
OUT	3	2	1	O	Analog voltage output.
VDD	4	1	3	P	Chip power supply port.
A1	5			I	Chip enable pin 1.

1. P = power, G = Ground, I = input, O = Output.

Table 1. Description of the GD30TS08XT SC70 package and connections of pin A0 and A1

PIN NAME	Chip model and corresponding connection method			
	GD30TS084T	GD30TS085T	GD30TS086T	GD30TS087T
A0	GND	VDD	GND	VDD
A1	GND	GND	VDD	VDD

5 Parameter Information

5.1 Absolute Maximum Ratings

Exceeding the operating temperature range (unless otherwise noted)[1]

SYMBOL	PARAMETER	MIN	MAX	UNIT
V_{DD}	Power supply		6	V
V_{OUT}	OUT Pin	GND	VDD+0.4	V
T_J	Junction Temperature		150	°C
T_{stg}	Storage Temperature	−60	150	°C

1. Over operating free-air temperature range (unless otherwise noted). Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.

5.2 Recommended Operation Conditions

PARAMETER	MIN	TYP	MAX	UNIT
Supply Voltage (VDD), GD30TS084T	1.5	3.3	5.5	V
Supply Voltage (VDD), GD30TS085T	1.8	3.3	5.5	V
Supply Voltage (VDD), GD30TS086T	2.2	3.3	5.5	V
Supply Voltage (VDD), GD30TS087T	2.7	3.3	5.5	V
GD30TS08XT Operating Temperature Range (T_A)	−55		140	°C

1. Unless otherwise stated, over operating free-air temperature range.

5.3 Electrical Sensitivity

SYMBOL[1]	CONDITIONS	VALUE	UNIT
$V_{ESD(HBM)}$	Human Body Mode (HBM), per ANSI/ESDA/JEDEC JS-001	±4000	V
$V_{ESD(MM)}$	Machine Mode (MM), per JEDEC-STD Classification	±200	V

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.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
VDD	Power Supply Voltage	GD30TS084T	1.5	3.3	5.5	V
		GD30TS085T	1.8	3.3	5.5	V
		GD30TS086T	2.2	3.3	5.5	V
		GD30TS087T	2.7	3.3	5.5	V
I_{VDD}	Supply current	Normal operation (VDD-OUT>200mV)		5.6	9.3	μA
T_{ERROR}	Accuracy (Temperature Error)	+25°C, +Vs = 3.3V		±0.4		°C
		−50°C to +140°C, +VS = 3.3 V		±1	±2.7	°C
	Power Supply Sensitivity	T_A =25° C, 3.0V <+Vs<5.5V		20	100	m°C/V
	Temperature range	GD30TS08XT	−55		140	°C
	Scale factor	GD30TS084T		–5.5		mV/°C
		GD30TS085T		–8.2		mV/°C
		GD30TS086T		–10.9		mV/°C
		GD30TS087T		–13.6		mV/°C
	Voltage linear regulation rate	GD30TS08XT		2.00		μV/V
I_{OUT}	Output load current		−50		50	μA
C_L	capacitive load drive			1		pF
t_{ON}	Device turn-on time	C_L =0pF to 1nF		0.7	2	ms

5.5 Typical Characteristics

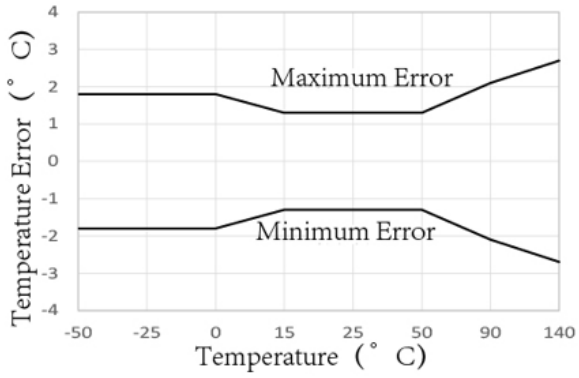


Figure 1. Temperature Error vs Temperature

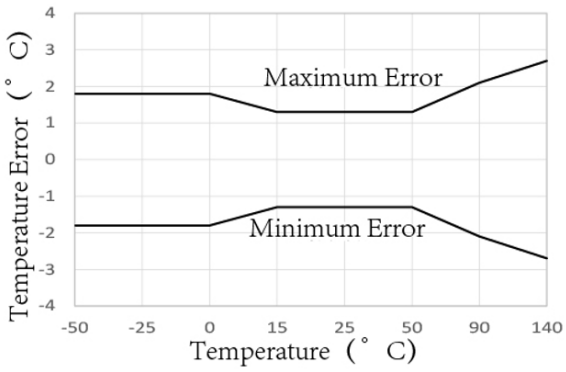


Figure 2. Operating Current vs Operating Temperature

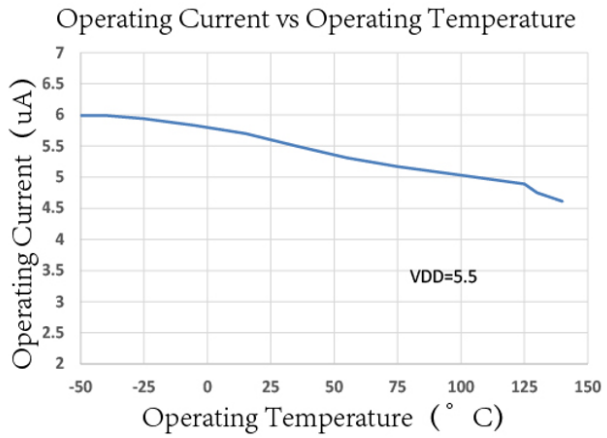


Figure 3. Current Load Adjustment

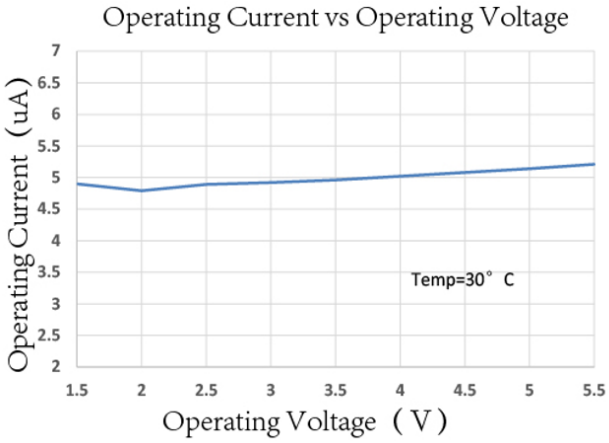


Figure 4. Sample test

6 Functional Description

6.1 Overview

The GD30TS08XT 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.

6.2 Functional Block Diagram

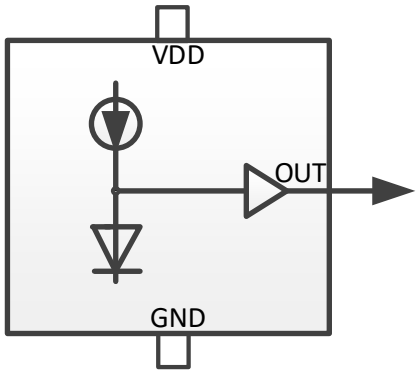


Figure 5. Internal Framework Diagram

6.3 Transfer Function

Table 2 shows the corresponding output voltage values of the GD30TS08XT series products at different temperatures. The data can be used in a look-up table.

Table 2. the relationship between the GD30TS08XT temperature and output voltage

Ambient Temperature (°C)	VOUT Output Voltage (mV)			
	GD30TS084T	GD30TS085T	GD30TS086T	GD30TS087T
−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

Ambient Temperature (°C)	VOUT Output Voltage (mV)			
	GD30TS084T	GD30TS085T	GD30TS086T	GD30TS087T
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 GD30TS08XT series sensor is relatively linear which can be seen from Table 3.

Table 3. The output voltage of the sensor can be approximately expressed by the following equation

The temperature of the GD30TS084T is calculated by the following approximate formula:

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

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

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

$$T_{84} = \frac{V_{OUT}(mV) - 870.6mV}{-5.506mV / ^{o}C} \quad (3)$$

The temperature of the GD30TS085T is calculated by the following approximate formula:

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

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

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

$$T_{84} = \frac{V_{OUT}(mV) - 1324.0mV}{-8.194mV / ^{o}C} \quad (6)$$

The temperature of the GD30TS086T is calculated by the following approximate formula:

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

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

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

$$T_{84} = \frac{V_{OUT}(mV) - 1777.3mV}{-10.888mV / ^{o}C} \quad (9)$$

The temperature of the GD30TS087T is calculated by the following approximate formula:

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

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

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

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

6.4 Thermal Conductivity and Installation Precautions

To ensure good thermal conductivity of the GD30TS08XT 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 GD30TS08XT will also affect the temperature reading. According to customer's application requirements, the GD30TS08XT can be made into a sealed metal probe for measuring the temperature of liquids. Like other IC applications, the GD30TS08XT 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 GD30TS08XT.

The chip self-heating calculation formula is as follows:

$$T_J = T_A + \Phi_{JA}\left[V_{DD} \times I_D + (V_{DD} - V_{OUT}) \times I_L\right] \quad (13)$$

Where:

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

T_A is the ambient temperature;

Φ_{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 SC70, in an application where T_A=30°C, Φ_{JA}=300$\frac{^{o}C}{W}$, V_{DD}=5V, I_D=5.4μA, V_{OUT}=1.7V, I_L=0μA , the junction temperature would be T_J = 30.008°C, indicating a self-heating error of only 0.015°C.

6.5 Filtering and Low-power Applications

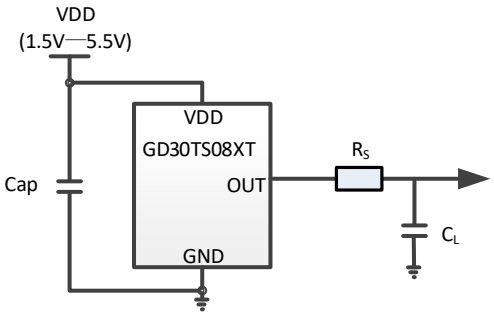


Figure 6. GD30TS08XT with Filter Capacitor Application

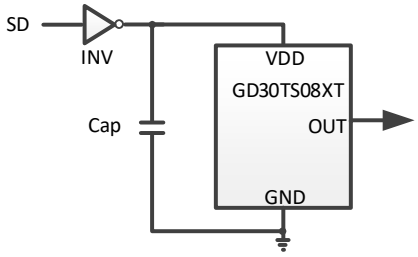


Figure 7. GD30TS08XT Low-power Application

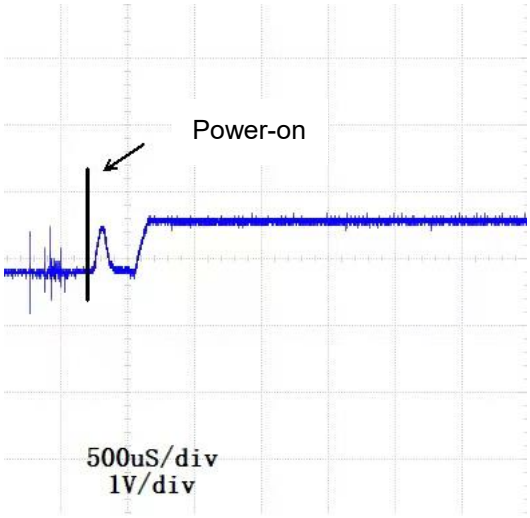


Figure 8. GD30TS08XT Startup Response Diagram

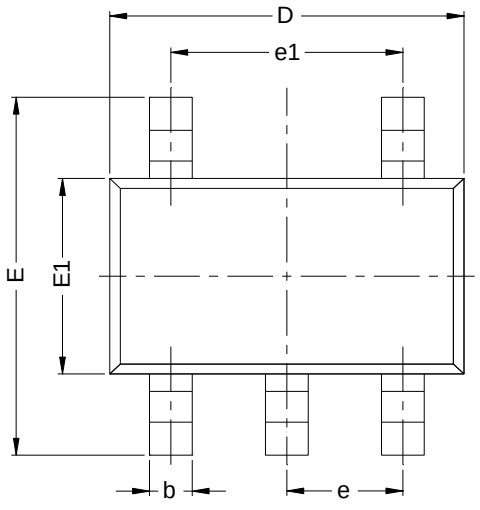
Table 4. Recommended values for peripheral circuits

CL	Minimum Resistance RS	Cap
<1.1nF	0kΩ	0.1uF
1.1nF to 99nF	3kΩ	0.1uF
100nF to 999nF	1.5kΩ	0.1uF
>1uF	800Ω	0.1uF

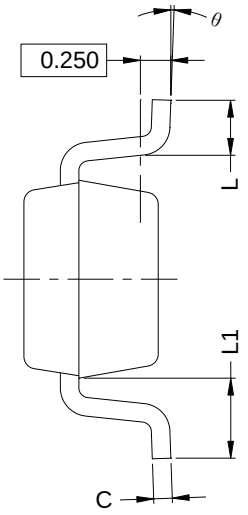
7 Package Information

7.1 Outline Dimensions

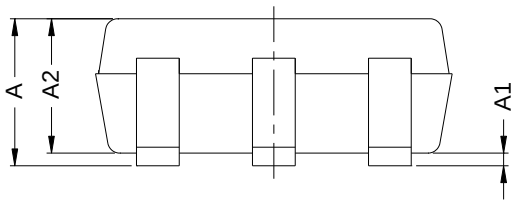
SC70 Package Outline



TOP VIEW



SIDE VIEW



FRONT VIEW

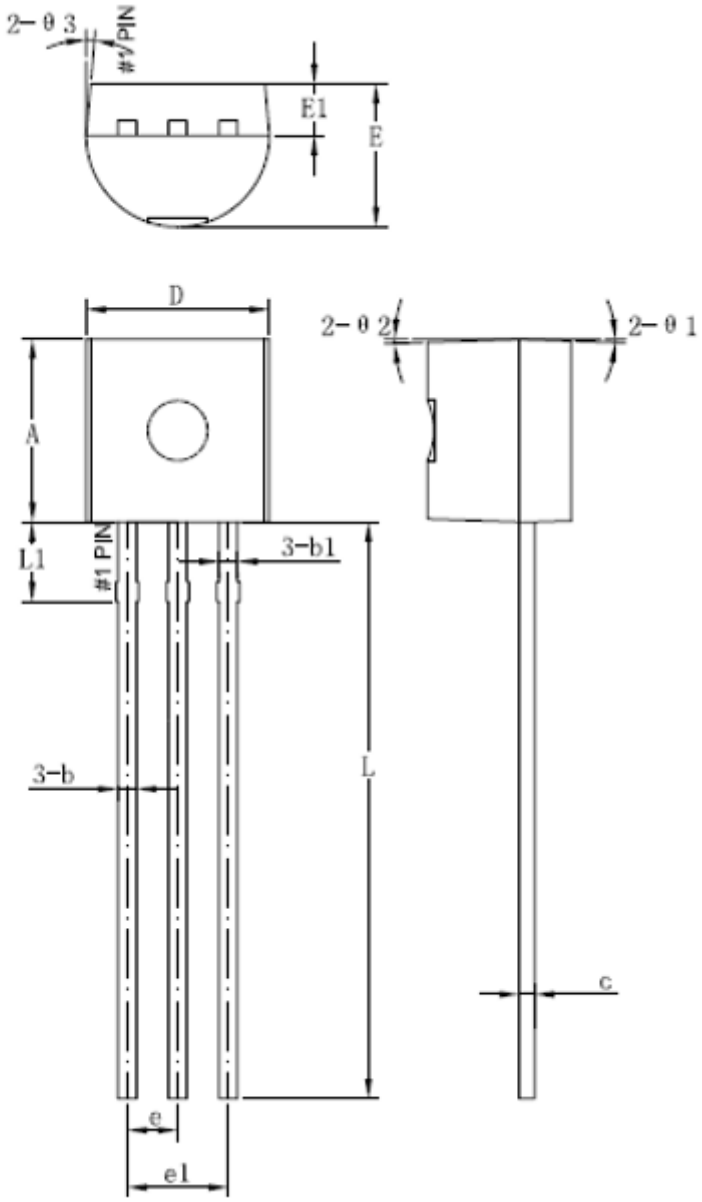
NOTES:

1. All dimensions are in millimeters.
2. Package dimensions does not include mold flash, protrusions, or gate burrs.
3. Refer to the *Table 5. SC70 dimensions(mm)*.

Table 5. SC70 dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	0.900	1.000	1.100
A1	0.000	0.050	0.100
A2	0.900	0.950	1.000
b	0.150	0.250	0.350
c	0.110		0.175
D	2.000	2.100	2.200
E1	1.150	1.250	1.350
E	2.150	2.300	2.450
e	0.65 TYP		
e1	1.200	1.300	1.400
L	0.260	0.360	0.460
L1	0.525 REF		
θ	0°		8°

TO-92 Package Outline



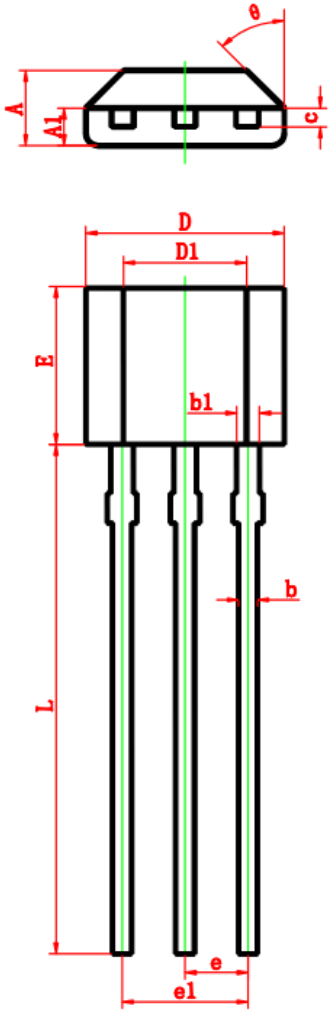
NOTES:

1. All dimensions are in millimeters.
2. Refer to the Table 6. *TO-92 dimensions(mm)*Table 5. SC70 dimensions(mm).

Table 6. TO-92 dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	4.50	4.60	4.70
b	0.38	0.46	0.56
b1		0.46	
c	0.36	0.38	0.51
D	4.50	4.60	4.70
E	3.45	3.60	3.75
E1	1.20	1.30	1.40
e		1.27	
e1		2.54	
L	13.50	14.5	15.30
L1		1.96	
θ 1		2°	
θ 2		2°	
θ 3		5°	

TO-92S Package Outline



NOTES:

1. All dimensions are in millimeters.
2. Refer to the Table 7. *TO-92S dimensions(mm)*Table 6. TO-92 dimensions(mm)Table 5. SC70 dimensions(mm).

Table 7. TO-92S dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	1.420		1.620
A1	0.660		0.860
b	0.330		0.480
b1	0.400		0.510
c	0.330		0.510
D	3.900		4.100
D1	2.280		2.680
E	3.050		3.250
e	1.270 TYP		
e1	2.440		2.640
L	15.100		15.500
θ	45°		

8 Ordering Information

Ordering Code	Package Type	ECO Plan	Packing Type	MOQ	OP Temp(°C)
GD30TS084TNSTR-I	SOT23-5	Green	Tape & Reel	3000	−55°C to +125°C
GD30TS084TB9BU-I	TO-92	Green	Bulk	2000	−55°C to +125°C
GD30TS084TBNBU-I	TO-92S	Green	Bulk	2000	−55°C to +125°C
GD30TS085TNSTR-I	SOT23-5	Green	Tape & Reel	3000	−55°C to +125°C
GD30TS085TB9BU-I	TO-92	Green	Bulk	2000	−55°C to +125°C
GD30TS085TBNBU-I	TO-92S	Green	Bulk	2000	−55°C to +125°C
GD30TS086TNSTR-I	SOT23-5	Green	Tape & Reel	3000	−55°C to +125°C
GD30TS086TB9BU-I	TO-92	Green	Bulk	2000	−55°C to +125°C
GD30TS086TBNBU-I	TO-92S	Green	Bulk	2000	−55°C to +125°C
GD30TS087TNSTR-I	SOT23-5	Green	Tape & Reel	3000	−55°C to +125°C
GD30TS087TB9BU-I	TO-92	Green	Bulk	2000	−55°C to +125°C
GD30TS087TBNBU-I	TO-92S	Green	Bulk	2000	−55°C to +125°C

9 Revision History

REVISION NUMBER	DESCRIPTION	DATE
1.0	Initial release and device details	2024

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