

LM35 Precision Centigrade Temperature Sensors

1 Features

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full –55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates From 4 V to 30 V
- Less Than 60-μA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

2 Applications

- Power Supplies
- Battery Management
- HVAC
- Appliances

3 Description

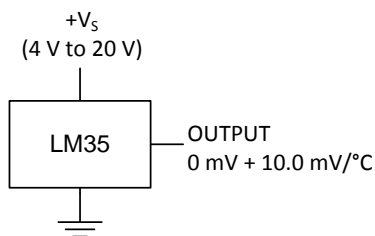
The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full –55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 μA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a –55°C to 150°C temperature range, while the LM35C device is rated for a –40°C to 110°C range (–10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

Device Information⁽¹⁾

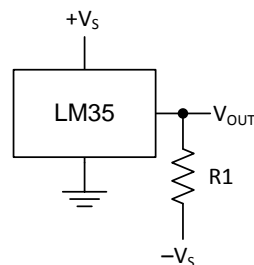
| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|-------------|------------|----------------------|
| LM35 | TO-CAN (3) | 4.699 mm × 4.699 mm |
| | TO-92 (3) | 4.30 mm × 4.30 mm |
| | SOIC (8) | 4.90 mm × 3.91 mm |
| | TO-220 (3) | 14.986 mm × 10.16 mm |

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Basic Centigrade Temperature Sensor (2°C to 150°C)



Full-Range Centigrade Temperature Sensor



Choose $R_1 = -V_S / 50 \mu\text{A}$
 $V_{\text{OUT}} = 1500 \text{ mV at } 150^\circ\text{C}$
 $V_{\text{OUT}} = 250 \text{ mV at } 25^\circ\text{C}$
 $V_{\text{OUT}} = -550 \text{ mV at } -55^\circ\text{C}$



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4 Revision History

| Changes from Revision G (August 2016) to Revision H | Page |
|---------------------------------------------------------------------------------------------------------|-------------|
| • Changed NDV Package (TO-CAN) pinout from bottom view back to top view; added textnote to pinout | 3 |
| • Added pin numbers to the TO-CAN (TO46) pinout | 3 |

| Changes from Revision F (January 2016) to Revision G | Page |
|---------------------------------------------------------------------------------------------------------------------------------|-------------|
| • Equation 1 , changed From: 10 mV/°F To: 10mv/°C | 13 |
| • Power Supply Recommendations , changed From: "4-V to 5.5-V power supply" To: "4-V to 30-V power supply: | 19 |

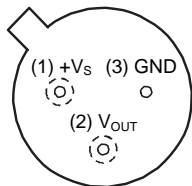
| Changes from Revision E (January 2015) to Revision F | Page |
|--------------------------------------------------------------------------|-------------|
| • Changed NDV Package (TO-CAN) pinout from Top View to Bottom View | 3 |

| Changes from Revision D (October 2013) to Revision E | Page |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| • Added <i>Pin Configuration and Functions</i> section, <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section | 1 |

| Changes from Revision C (July 2013) to Revision D | Page |
|-------------------------------------------------------------|-------------|
| • Changed W to Ω | 1 |
| • Changed W to Ω in <i>Abs Max</i> tablenote. | 4 |

5 Pin Configuration and Functions

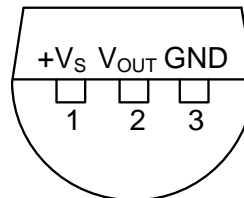
**NDV Package
3-Pin TO-CAN
(Top View)**



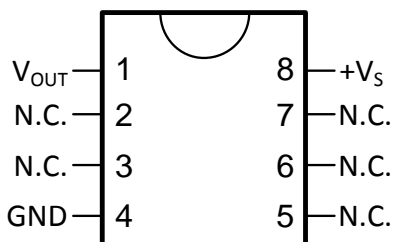
Case is connected to negative pin (GND)

Refer the second NDV0003H page for reference

**LP Package
3-Pin TO-92
(Bottom View)**

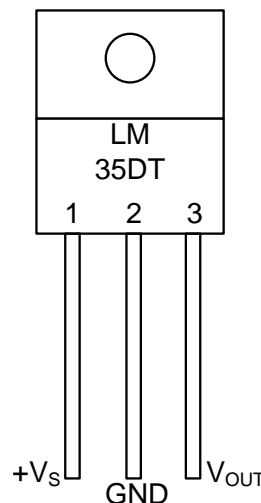


**D Package
8-PIN SOIC
(Top View)**



N.C. = No connection

**NEB Package
3-Pin TO-220
(Top View)**



Tab is connected to the negative pin (GND).

NOTE: The LM35DT pinout is different than the discontinued LM35DP

Pin Functions

| NAME | PIN | | | | TYPE | DESCRIPTION |
|------------------|------|------|-------|-----|--------|--------------------------------------------------------------|
| | TO46 | TO92 | TO220 | SO8 | | |
| V _{OUT} | 2 | 2 | 3 | 1 | O | Temperature Sensor Analog Output |
| N.C. | — | — | — | 2 | — | No Connection |
| | — | — | — | 3 | | |
| GND | 3 | 3 | 2 | 4 | GROUND | Device ground pin, connect to power supply negative terminal |
| N.C. | — | — | — | 5 | — | No Connection |
| | — | — | — | 6 | | |
| | — | — | — | 7 | | |
| +V _S | 1 | 1 | 1 | 8 | POWER | Positive power supply pin |

6 Specifications

6.1 Absolute Maximum Ratings

 over operating free-air temperature range (unless otherwise noted)⁽¹⁾⁽²⁾

| | | MIN | MAX | UNIT |
|-------------------------------------------------|-----------------------|------|-----|------|
| Supply voltage | | -0.2 | 35 | V |
| Output voltage | | -1 | 6 | V |
| Output current | | | 10 | mA |
| Maximum Junction Temperature, T _{Jmax} | | | 150 | °C |
| Storage Temperature, T _{stg} | TO-CAN, TO-92 Package | -60 | 150 | °C |
| | TO-220, SOIC Package | -65 | 150 | |

- (1) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (2) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions.

6.2 ESD Ratings

| | | | VALUE | UNIT |
|--------------------|-------------------------|-------------------------------------------------------------------|-------|------|
| V _(ESD) | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±2500 | V |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|-----------------------------------------------------------------------|---------------|-----|-----|------|
| Specified operating temperature: T _{MIN} to T _{MAX} | LM35, LM35A | -55 | 150 | °C |
| | LM35C, LM35CA | -40 | 110 | |
| | LM35D | 0 | 100 | |
| Supply Voltage (+V _S) | | 4 | 30 | V |

6.4 Thermal Information

| THERMAL METRIC ⁽¹⁾⁽²⁾ | LM35 | | | | UNIT |
|-----------------------------------------------------------------|--------|-----|--------|--------|------|
| | NDV | LP | D | NEB | |
| | 3 PINS | | 8 PINS | 3 PINS | |
| R _{θJA} Junction-to-ambient thermal resistance | 400 | 180 | 220 | 90 | °C/W |
| R _{θJC(top)} Junction-to-case (top) thermal resistance | 24 | — | — | — | |

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).
- (2) For additional thermal resistance information, see [Typical Application](#).

6.5 Electrical Characteristics: LM35A, LM35CA Limits

Unless otherwise noted, these specifications apply: $-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ for the LM35 and LM35A; $-40^{\circ}\text{C} \leq T_J \leq 110^{\circ}\text{C}$ for the LM35C and LM35CA; and $0^{\circ}\text{C} \leq T_J \leq 100^{\circ}\text{C}$ for the LM35D. $V_S = 5\text{ Vdc}$ and $I_{\text{LOAD}} = 50\ \mu\text{A}$, in the circuit of [Full-Range Centigrade Temperature Sensor](#). These specifications also apply from 2°C to T_{MAX} in the circuit of [Figure 14](#).

| PARAMETER | TEST CONDITIONS | LM35A | | | LM35CA | | | UNIT |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------|-----------------------------|-----------------------------|------------|-----------------------------|-----------------------------|--------------------------------|
| | | TYP | TESTED LIMIT ⁽¹⁾ | DESIGN LIMIT ⁽²⁾ | TYP | TESTED LIMIT ⁽¹⁾ | DESIGN LIMIT ⁽²⁾ | |
| Accuracy ⁽³⁾ | $T_A = 25^{\circ}\text{C}$ | ± 0.2 | ± 0.5 | | ± 0.2 | ± 0.5 | | $^{\circ}\text{C}$ |
| | $T_A = -10^{\circ}\text{C}$ | ± 0.3 | | | ± 0.3 | | ± 1 | |
| | $T_A = T_{\text{MAX}}$ | ± 0.4 | ± 1 | | ± 0.4 | ± 1 | | |
| | $T_A = T_{\text{MIN}}$ | ± 0.4 | ± 1 | | ± 0.4 | | ± 1.5 | |
| Nonlinearity ⁽⁴⁾ | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | ± 0.18 | | ± 0.35 | ± 0.15 | | ± 0.3 | $^{\circ}\text{C}$ |
| Sensor gain (average slope) | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$ | 10 | 9.9 | | 10 | | 9.9 | $\text{mV}/^{\circ}\text{C}$ |
| | $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 10 | 10.1 | | 10 | | 10.1 | |
| Load regulation ⁽⁵⁾ $0 \leq I_L \leq 1\ \text{mA}$ | $T_A = 25^{\circ}\text{C}$ | ± 0.4 | ± 1 | | ± 0.4 | ± 1 | | mV/mA |
| | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | ± 0.5 | | ± 3 | ± 0.5 | | ± 3 | |
| Line regulation ⁽⁵⁾ | $T_A = 25^{\circ}\text{C}$ | ± 0.01 | ± 0.05 | | ± 0.01 | ± 0.05 | | mV/V |
| | $4\ \text{V} \leq V_S \leq 30\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | ± 0.02 | | ± 0.1 | ± 0.02 | | ± 0.1 | |
| Quiescent current ⁽⁶⁾ | $V_S = 5\ \text{V}$, 25°C | 56 | 67 | | 56 | 67 | | μA |
| | $V_S = 5\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 105 | | 131 | 91 | | 114 | |
| | $V_S = 30\ \text{V}$, 25°C | 56.2 | 68 | | 56.2 | 68 | | |
| | $V_S = 30\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 105.5 | | 133 | 91.5 | | 116 | |
| Change of quiescent current ⁽⁵⁾ | $4\ \text{V} \leq V_S \leq 30\ \text{V}$, 25°C | 0.2 | 1 | | 0.2 | 1 | | μA |
| | $4\ \text{V} \leq V_S \leq 30\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 0.5 | | 2 | 0.5 | | 2 | |
| Temperature coefficient of quiescent current | $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 0.39 | | 0.5 | 0.39 | | 0.5 | $\mu\text{A}/^{\circ}\text{C}$ |
| Minimum temperature for rate accuracy | In circuit of Figure 14 , $I_L = 0$ | 1.5 | | 2 | 1.5 | | 2 | $^{\circ}\text{C}$ |
| Long term stability | $T_J = T_{\text{MAX}}$, for 1000 hours | ± 0.08 | | | ± 0.08 | | | $^{\circ}\text{C}$ |

- (1) Tested Limits are ensured and 100% tested in production.
- (2) Design Limits are ensured (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.
- (3) Accuracy is defined as the error between the output voltage and $10\ \text{mV}/^{\circ}\text{C}$ times the case temperature of the device, at specified conditions of voltage, current, and temperature (expressed in $^{\circ}\text{C}$).
- (4) Non-linearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the rated temperature range of the device.
- (5) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.
- (6) Quiescent current is defined in the circuit of [Figure 14](#).

6.6 Electrical Characteristics: LM35A, LM35CA

Unless otherwise noted, these specifications apply: $-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ for the LM35 and LM35A; $-40^{\circ}\text{C} \leq T_J \leq 110^{\circ}\text{C}$ for the LM35C and LM35CA; and $0^{\circ}\text{C} \leq T_J \leq 100^{\circ}\text{C}$ for the LM35D. $V_S = 5\text{ Vdc}$ and $I_{\text{LOAD}} = 50\ \mu\text{A}$, in the circuit of [Full-Range Centigrade Temperature Sensor](#). These specifications also apply from 2°C to T_{MAX} in the circuit of [Figure 14](#).

| PARAMETER | TEST CONDITIONS | LM35A | | | LM35CA | | | UNIT |
|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-----------------------------|------------|------------|------------|------------|-------|-----------|
| | | MIN | TYP | MAX | TYP | TYP | MAX | |
| Accuracy ⁽¹⁾ | $T_A = 25^{\circ}\text{C}$ | | ± 0.2 | | ± 0.2 | | °C | |
| | | Tested Limit ⁽²⁾ | | ± 0.5 | | ± 0.5 | | |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $T_A = -10^{\circ}\text{C}$ | | ± 0.3 | | ± 0.3 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 1 | | |
| | $T_A = T_{\text{MAX}}$ | | ± 0.4 | | ± 1 | ± 0.4 | | |
| | | Tested Limit ⁽²⁾ | | | | | | ± 1 |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $T_A = T_{\text{MIN}}$ | | ± 0.4 | | ± 1 | ± 0.4 | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | | | | | ± 1.5 |
| Nonlinearity ⁽⁴⁾ | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | ± 0.18 | | ± 0.15 | | °C | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | ± 0.35 | | ± 0.3 | | |
| Sensor gain (average slope) | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$ | | 10 | | 10 | | mV/°C | |
| | | Tested Limit ⁽²⁾ | | 9.9 | | | | |
| | | Design Limit ⁽³⁾ | | | | 9.9 | | |
| | $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | 10 | | 10 | | | |
| | | Tested Limit ⁽²⁾ | | 10.1 | | | | |
| | | Design Limit ⁽³⁾ | | | | 10.1 | | |
| Load regulation ⁽⁵⁾ $0 \leq I_L \leq 1\text{ mA}$ | $T_A = 25^{\circ}\text{C}$ | | ± 0.4 | | ± 0.4 | | mV/mA | |
| | | Tested Limit ⁽²⁾ | | ± 1 | | ± 1 | | |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | ± 0.5 | | ± 0.5 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | ± 3 | | ± 3 | | |
| Line regulation ⁽⁵⁾ | $T_A = 25^{\circ}\text{C}$ | | ± 0.01 | | ± 0.01 | | mV/V | |
| | | Tested Limit ⁽²⁾ | | ± 0.05 | | ± 0.05 | | |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $4\text{ V} \leq V_S \leq 30\text{ V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | ± 0.02 | | ± 0.02 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | ± 0.1 | | ± 0.1 | | |

- (1) Accuracy is defined as the error between the output voltage and 10 mV/°C times the case temperature of the device, at specified conditions of voltage, current, and temperature (expressed in °C).
- (2) Tested Limits are ensured and 100% tested in production.
- (3) Design Limits are ensured (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.
- (4) Non-linearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the rated temperature range of the device.
- (5) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.

Electrical Characteristics: LM35A, LM35CA (continued)

Unless otherwise noted, these specifications apply: $-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ for the LM35 and LM35A; $-40^{\circ}\text{C} \leq T_J \leq 110^{\circ}\text{C}$ for the LM35C and LM35CA; and $0^{\circ}\text{C} \leq T_J \leq 100^{\circ}\text{C}$ for the LM35D. $V_S = 5\text{ Vdc}$ and $I_{\text{LOAD}} = 50\ \mu\text{A}$, in the circuit of [Full-Range Centigrade Temperature Sensor](#). These specifications also apply from 2°C to T_{MAX} in the circuit of [Figure 14](#).

| PARAMETER | TEST CONDITIONS | LM35A | | | LM35CA | | | UNIT |
|----------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------|------------|-------|------------|------|--------------------------------|------|
| | | MIN | TYP | MAX | TYP | TYP | MAX | |
| Quiescent current ⁽⁶⁾ | $V_S = 5\text{ V}, 25^{\circ}\text{C}$ | | 56 | | 56 | | μA | |
| | | Tested Limit ⁽²⁾ | | 67 | | 67 | | |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $V_S = 5\text{ V}, -40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | | 105 | | 91 | | |
| | | Tested Limit ⁽²⁾ | | | 131 | | | 114 |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $V_S = 30\text{ V}, 25^{\circ}\text{C}$ | | | 56.2 | | 56.2 | | |
| | | Tested Limit ⁽²⁾ | | | 68 | | | 68 |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $V_S = 30\text{ V}, -40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | | 105.5 | | 91.5 | | |
| | | Tested Limit ⁽²⁾ | | | 133 | | | 116 |
| | | Design Limit ⁽³⁾ | | | | | | |
| Change of quiescent current ⁽⁵⁾ | $4\text{ V} \leq V_S \leq 30\text{ V}, 25^{\circ}\text{C}$ | | 0.2 | | 0.2 | | μA | |
| | | Tested Limit ⁽²⁾ | | 1 | | 1 | | |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $4\text{ V} \leq V_S \leq 30\text{ V}, -40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | | 0.5 | | 0.5 | | |
| | | Tested Limit ⁽²⁾ | | | 2 | | | 2 |
| | | Design Limit ⁽³⁾ | | | | | | |
| Temperature coefficient of quiescent current | $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | 0.39 | | 0.39 | | $\mu\text{A}/^{\circ}\text{C}$ | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | 0.5 | | 0.5 | | |
| Minimum temperature for rate accuracy | In circuit of Figure 14 , $I_L = 0$ | | 1.5 | | 1.5 | | $^{\circ}\text{C}$ | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | 2 | | 2 | | |
| Long term stability | $T_J = T_{\text{MAX}}$, for 1000 hours | | ± 0.08 | | ± 0.08 | | $^{\circ}\text{C}$ | |

(6) Quiescent current is defined in the circuit of [Figure 14](#).

6.7 Electrical Characteristics: LM35, LM35C, LM35D Limits

Unless otherwise noted, these specifications apply: $-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ for the LM35 and LM35A; $-40^{\circ}\text{C} \leq T_J \leq 110^{\circ}\text{C}$ for the LM35C and LM35CA; and $0^{\circ}\text{C} \leq T_J \leq 100^{\circ}\text{C}$ for the LM35D. $V_S = 5\text{ Vdc}$ and $I_{\text{LOAD}} = 50\ \mu\text{A}$, in the circuit of [Full-Range Centigrade Temperature Sensor](#). These specifications also apply from 2°C to T_{MAX} in the circuit of [Figure 14](#).

| PARAMETER | TEST CONDITIONS | LM35 | | | LM35C, LM35D | | | UNIT |
|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------|-----------------------------|-----------------------------|--------------|-----------------------------|-----------------------------|--------------------------------|
| | | TYP | TESTED LIMIT ⁽¹⁾ | DESIGN LIMIT ⁽²⁾ | TYP | TESTED LIMIT ⁽¹⁾ | DESIGN LIMIT ⁽²⁾ | |
| Accuracy, LM35, LM35C ⁽³⁾ | $T_A = 25^{\circ}\text{C}$ | ± 0.4 | ± 1 | | ± 0.4 | ± 1 | | $^{\circ}\text{C}$ |
| | $T_A = -10^{\circ}\text{C}$ | ± 0.5 | | | ± 0.5 | | ± 1.5 | |
| | $T_A = T_{\text{MAX}}$ | ± 0.8 | ± 1.5 | | ± 0.8 | | ± 1.5 | |
| | $T_A = T_{\text{MIN}}$ | ± 0.8 | | ± 1.5 | ± 0.8 | | ± 2 | |
| Accuracy, LM35D ⁽³⁾ | $T_A = 25^{\circ}\text{C}$ | | | | ± 0.6 | ± 1.5 | | $^{\circ}\text{C}$ |
| | $T_A = T_{\text{MAX}}$ | | | | ± 0.9 | | ± 2 | |
| | $T_A = T_{\text{MIN}}$ | | | | ± 0.9 | | ± 2 | |
| Nonlinearity ⁽⁴⁾ | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | ± 0.3 | | ± 0.5 | ± 0.2 | | ± 0.5 | $^{\circ}\text{C}$ |
| Sensor gain (average slope) | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 10 | 9.8 | | 10 | | 9.8 | $\text{mV}/^{\circ}\text{C}$ |
| | | 10 | 10.2 | | 10 | | 10.2 | |
| Load regulation ⁽⁵⁾ $0 \leq I_L \leq 1\ \text{mA}$ | $T_A = 25^{\circ}\text{C}$ | ± 0.4 | ± 2 | | ± 0.4 | ± 2 | | mV/mA |
| | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | ± 0.5 | | ± 5 | ± 0.5 | | ± 5 | |
| Line regulation ⁽⁵⁾ | $T_A = 25^{\circ}\text{C}$ | ± 0.01 | ± 0.1 | | ± 0.01 | ± 0.1 | | mV/V |
| | $4\ \text{V} \leq V_S \leq 30\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | ± 0.02 | | ± 0.2 | ± 0.02 | | ± 0.2 | |
| Quiescent current ⁽⁶⁾ | $V_S = 5\ \text{V}$, 25°C | 56 | 80 | | 56 | 80 | | μA |
| | $V_S = 5\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 105 | | 158 | 91 | | 138 | |
| | $V_S = 30\ \text{V}$, 25°C | 56.2 | 82 | | 56.2 | 82 | | |
| | $V_S = 30\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 105.5 | | 161 | 91.5 | | 141 | |
| Change of quiescent current ⁽⁵⁾ | $4\ \text{V} \leq V_S \leq 30\ \text{V}$, 25°C | 0.2 | 2 | | 0.2 | 2 | | μA |
| | $4\ \text{V} \leq V_S \leq 30\ \text{V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 0.5 | | 3 | 0.5 | | 3 | |
| Temperature coefficient of quiescent current | $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | 0.39 | | 0.7 | 0.39 | | 0.7 | $\mu\text{A}/^{\circ}\text{C}$ |
| Minimum temperature for rate accuracy | In circuit of Figure 14 , $I_L = 0$ | 1.5 | | 2 | 1.5 | | 2 | $^{\circ}\text{C}$ |
| Long term stability | $T_J = T_{\text{MAX}}$, for 1000 hours | ± 0.08 | | | ± 0.08 | | | $^{\circ}\text{C}$ |

- (1) Tested Limits are ensured and 100% tested in production.
- (2) Design Limits are ensured (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.
- (3) Accuracy is defined as the error between the output voltage and $10\ \text{mV}/^{\circ}\text{C}$ times the case temperature of the device, at specified conditions of voltage, current, and temperature (expressed in $^{\circ}\text{C}$).
- (4) Non-linearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the rated temperature range of the device.
- (5) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.
- (6) Quiescent current is defined in the circuit of [Figure 14](#).

6.8 Electrical Characteristics: LM35, LM35C, LM35D

Unless otherwise noted, these specifications apply: $-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ for the LM35 and LM35A; $-40^{\circ}\text{C} \leq T_J \leq 110^{\circ}\text{C}$ for the LM35C and LM35CA; and $0^{\circ}\text{C} \leq T_J \leq 100^{\circ}\text{C}$ for the LM35D. $V_S = 5\text{ Vdc}$ and $I_{\text{LOAD}} = 50\ \mu\text{A}$, in the circuit of [Full-Range Centigrade Temperature Sensor](#). These specifications also apply from 2°C to T_{MAX} in the circuit of [Figure 14](#).

| PARAMETER | TEST CONDITIONS | | LM35 | | | LM35C, LM35D | | | UNIT |
|-----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------|-----------|-----|-----|--------------|-----|-----|-------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| Accuracy, LM35, LM35C ⁽¹⁾ | $T_A = 25^{\circ}\text{C}$ | | ± 0.4 | | | ± 0.4 | | | °C |
| | | Tested Limit ⁽²⁾ | | | | ± 1 | | | |
| | | Design Limit ⁽³⁾ | | | | | | | |
| | $T_A = -10^{\circ}\text{C}$ | | ± 0.5 | | | ± 0.5 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 1.5 | | | |
| | $T_A = T_{\text{MAX}}$ | | ± 0.8 | | | ± 0.8 | | | |
| | | Tested Limit ⁽²⁾ | | | | ± 1.5 | | | |
| | | Design Limit ⁽³⁾ | | | | ± 1.5 | | | |
| | $T_A = T_{\text{MIN}}$ | | ± 0.8 | | | ± 0.8 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 2 | | | |
| Accuracy, LM35D ⁽¹⁾ | $T_A = 25^{\circ}\text{C}$ | | | | | ± 0.6 | | | °C |
| | | Tested Limit ⁽²⁾ | | | | ± 1.5 | | | |
| | | Design Limit ⁽³⁾ | | | | | | | |
| | $T_A = T_{\text{MAX}}$ | | | | | ± 0.9 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 2 | | | |
| | $T_A = T_{\text{MIN}}$ | | | | | ± 0.9 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 2 | | | |
| Nonlinearity ⁽⁴⁾ | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}},$ $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | ± 0.3 | | | ± 0.2 | | | °C |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 0.5 | | | |
| Sensor gain (average slope) | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}},$ $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | 10 | | | 10 | | | mV/°C |
| | | Tested Limit ⁽²⁾ | | | | 9.8 | | | |
| | | Design Limit ⁽³⁾ | | | | 9.8 | | | |
| | | | 10 | | | 10 | | | |
| | | Tested Limit ⁽²⁾ | | | | 10.2 | | | |
| | | Design Limit ⁽³⁾ | | | | 10.2 | | | |
| Load regulation ⁽⁵⁾ $0 \leq I_L \leq 1\text{ mA}$ | $T_A = 25^{\circ}\text{C}$ | | ± 0.4 | | | ± 0.4 | | | mV/mA |
| | | Tested Limit ⁽²⁾ | | | | ± 2 | | | |
| | | Design Limit ⁽³⁾ | | | | | | | |
| | $T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}},$ $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | ± 0.5 | | | ± 0.5 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 5 | | | |

- (1) Accuracy is defined as the error between the output voltage and 10 mV/°C times the case temperature of the device, at specified conditions of voltage, current, and temperature (expressed in °C).
- (2) Tested Limits are ensured and 100% tested in production.
- (3) Design Limits are ensured (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.
- (4) Non-linearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the rated temperature range of the device.
- (5) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.

Electrical Characteristics: LM35, LM35C, LM35D (continued)

Unless otherwise noted, these specifications apply: $-55^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$ for the LM35 and LM35A; $-40^{\circ}\text{C} \leq T_J \leq 110^{\circ}\text{C}$ for the LM35C and LM35CA; and $0^{\circ}\text{C} \leq T_J \leq 100^{\circ}\text{C}$ for the LM35D. $V_S = 5\text{ Vdc}$ and $I_{\text{LOAD}} = 50\ \mu\text{A}$, in the circuit of [Full-Range Centigrade Temperature Sensor](#). These specifications also apply from 2°C to T_{MAX} in the circuit of [Figure 14](#).

| PARAMETER | TEST CONDITIONS | LM35 | | | LM35C, LM35D | | | UNIT |
|----------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------|------------|-----------|--------------|-----------|--------------------------------|------|
| | | MIN | TYP | MAX | MIN | TYP | MAX | |
| Line regulation ⁽⁵⁾ | $T_A = 25^{\circ}\text{C}$ | | ± 0.01 | | ± 0.01 | | mV/V | |
| | | Tested Limit ⁽²⁾ | | ± 0.1 | | | | |
| | | Design Limit ⁽³⁾ | | | | ± 0.1 | | |
| | $4\text{ V} \leq V_S \leq 30\text{ V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | ± 0.02 | | ± 0.02 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | ± 0.2 | | ± 0.2 | | |
| Quiescent current ⁽⁶⁾ | $V_S = 5\text{ V}$, 25°C | | 56 | | 56 | | μA | |
| | | Tested Limit ⁽²⁾ | | 80 | | 80 | | |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $V_S = 5\text{ V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | | 105 | | 91 | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | 158 | | 138 | | |
| | $V_S = 30\text{ V}$, 25°C | | 56.2 | | 56.2 | | | |
| | | Tested Limit ⁽²⁾ | | 82 | | 82 | | |
| | | Design Limit ⁽³⁾ | | | | | | |
| | $V_S = 30\text{ V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | | 105.5 | | 91.5 | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | 161 | | 141 | | |
| Change of quiescent current ⁽⁵⁾ | $4\text{ V} \leq V_S \leq 30\text{ V}$, 25°C | | 0.2 | | 0.2 | | μA | |
| | | Tested Limit ⁽²⁾ | | | | 2 | | |
| | | Design Limit ⁽³⁾ | | 2 | | | | |
| | $4\text{ V} \leq V_S \leq 30\text{ V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | | 0.5 | | 0.5 | | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | 3 | | 3 | | |
| Temperature coefficient of quiescent current | $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | 0.39 | | 0.39 | | $\mu\text{A}/^{\circ}\text{C}$ | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | 0.7 | | 0.7 | | |
| Minimum temperature for rate accuracy | In circuit of Figure 14 , $I_L = 0$ | | 1.5 | | 1.5 | | $^{\circ}\text{C}$ | |
| | | Tested Limit ⁽²⁾ | | | | | | |
| | | Design Limit ⁽³⁾ | | 2 | | 2 | | |
| Long term stability | $T_J = T_{\text{MAX}}$, for 1000 hours | | ± 0.08 | | ± 0.08 | | $^{\circ}\text{C}$ | |

(6) Quiescent current is defined in the circuit of [Figure 14](#).

6.9 Typical Characteristics

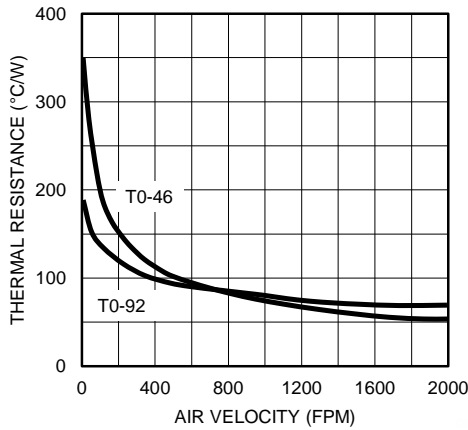


Figure 1. Thermal Resistance Junction To Air

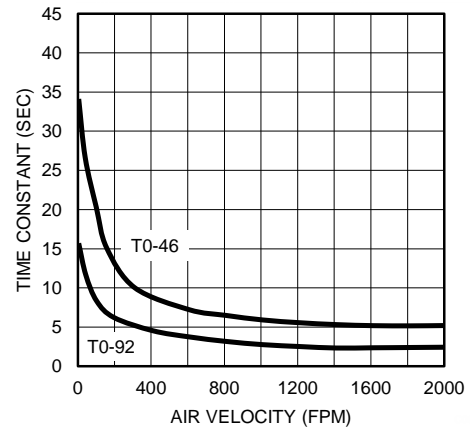


Figure 2. Thermal Time Constant

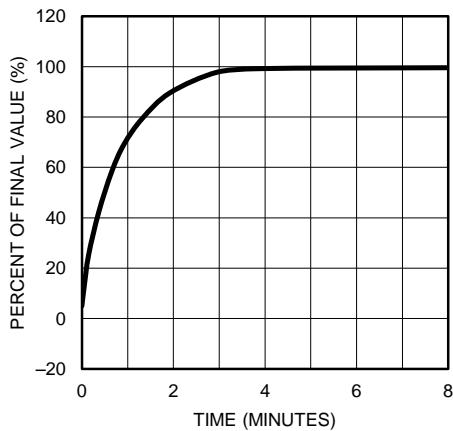


Figure 3. Thermal Response In Still Air

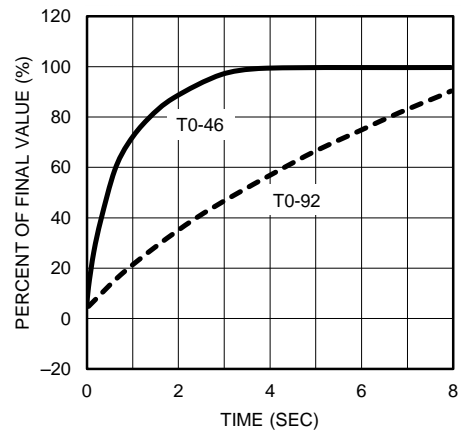


Figure 4. Thermal Response In Stirred Oil Bath

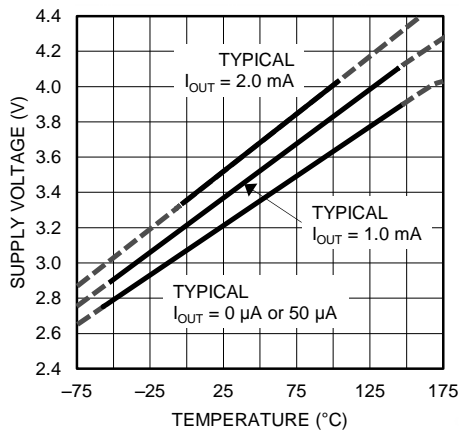


Figure 5. Minimum Supply Voltage vs Temperature

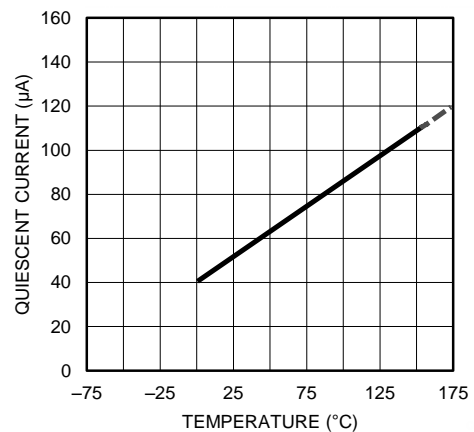


Figure 6. Quiescent Current vs Temperature (in Circuit of Figure 14)

Typical Characteristics (continued)

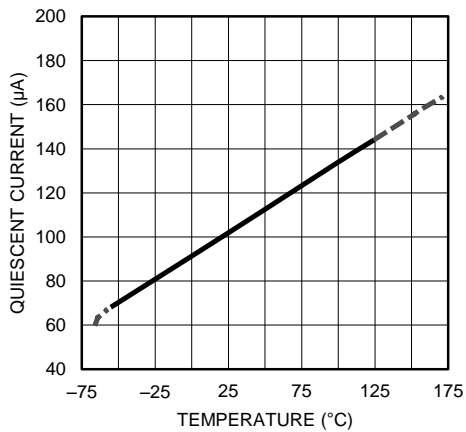


Figure 7. Quiescent Current vs Temperature (in Circuit of Full-Range Centigrade Temperature Sensor)

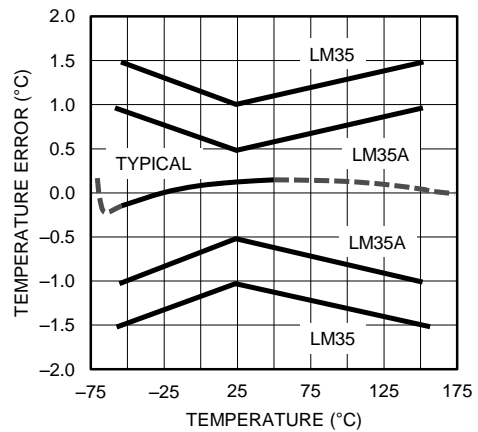


Figure 8. Accuracy vs Temperature (Ensured)

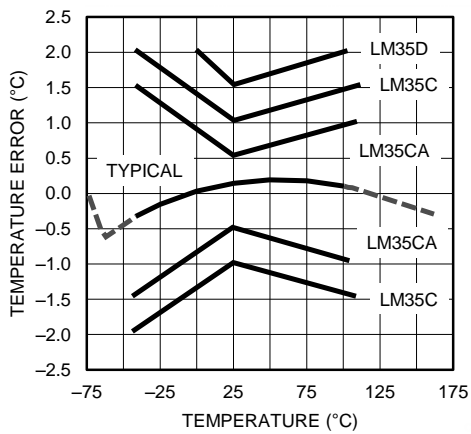


Figure 9. Accuracy vs Temperature (Ensured)

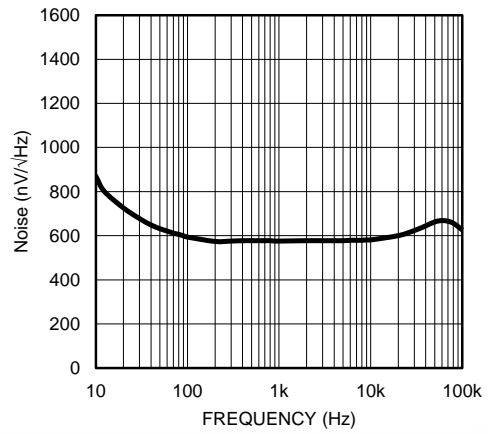


Figure 10. Noise Voltage

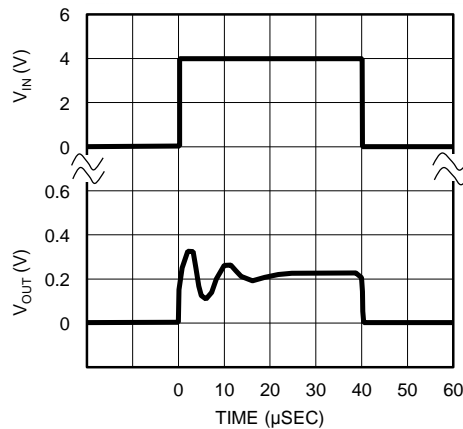


Figure 11. Start-Up Response

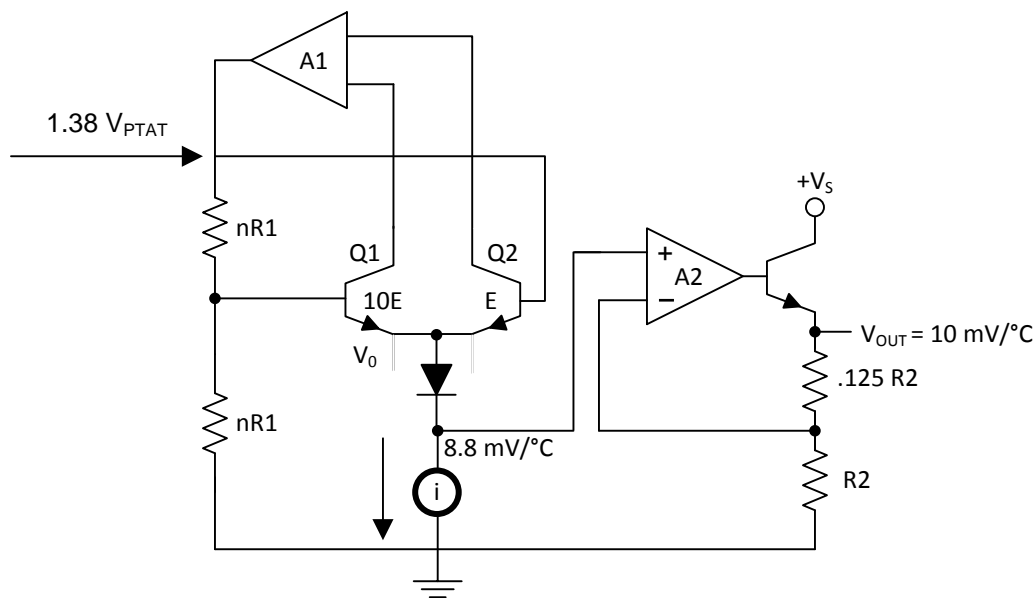
7 Detailed Description

7.1 Overview

The LM35-series devices are precision integrated-circuit temperature sensors, with an output voltage linearly proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of $\pm 1/4^\circ\text{C}$ at room temperature and $\pm 3/4^\circ\text{C}$ over a full -55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only $60\ \mu\text{A}$ from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a -55°C to 150°C temperature range, while the LM35C device is rated for a -40°C to 110°C range (-10° with improved accuracy). The temperature-sensing element is comprised of a delta-V BE architecture.

The temperature-sensing element is then buffered by an amplifier and provided to the VOUT pin. The amplifier has a simple class A output stage with typical $0.5\text{-}\Omega$ output impedance as shown in the *Functional Block Diagram*. Therefore the LM35 can only source current and its sinking capability is limited to $1\ \mu\text{A}$.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 LM35 Transfer Function

The accuracy specifications of the LM35 are given with respect to a simple linear transfer function:

$$V_{\text{OUT}} = 10\ \text{mV}/^\circ\text{C} \times T$$

where

- V_{OUT} is the LM35 output voltage
- T is the temperature in $^\circ\text{C}$

(1)

7.4 Device Functional Modes

The only functional mode of the LM35 is that it has an analog output directly proportional to temperature.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The features of the LM35 make it suitable for many general temperature sensing applications. Multiple package options expand on its flexibility.

8.1.1 Capacitive Drive Capability

Like most micropower circuits, the LM35 device has a limited ability to drive heavy capacitive loads. Alone, the LM35 device is able to drive 50 pF without special precautions. If heavier loads are anticipated, isolating or decoupling the load with a resistor is easy (see Figure 12). The tolerance of capacitance can be improved with a series R-C damper from output to ground (see Figure 13).

When the LM35 device is applied with a 200-Ω load resistor as shown in Figure 16, Figure 17, or Figure 19, the device is relatively immune to wiring capacitance because the capacitance forms a bypass from ground to input and not on the output. However, as with any linear circuit connected to wires in a hostile environment, performance is affected adversely by intense electromagnetic sources (such as relays, radio transmitters, motors with arcing brushes, and SCR transients), because the wiring acts as a receiving antenna and the internal junctions act as rectifiers. For best results in such cases, a bypass capacitor from V_{IN} to ground and a series R-C damper, such as 75 Ω in series with 0.2 or 1 μF from output to ground, are often useful. Examples are shown in Figure 13, Figure 24, and Figure 25.

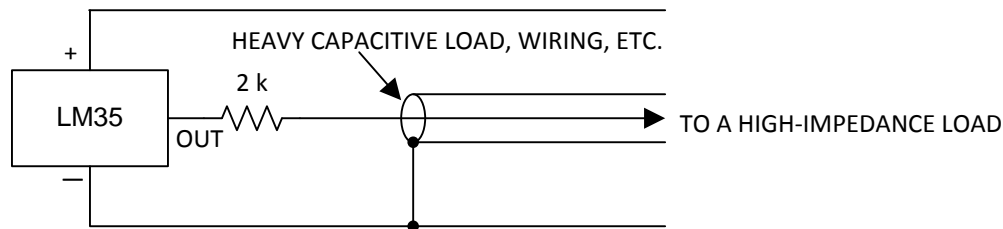


Figure 12. LM35 with Decoupling from Capacitive Load

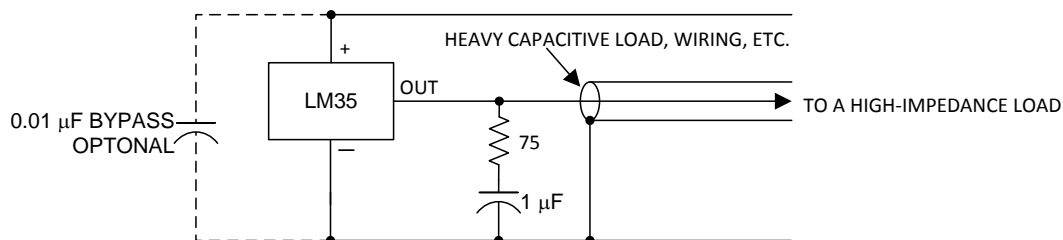


Figure 13. LM35 with R-C Damper

8.2 Typical Application

8.2.1 Basic Centigrade Temperature Sensor

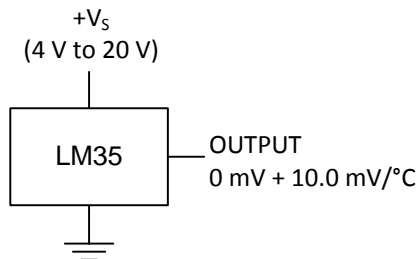


Figure 14. Basic Centigrade Temperature Sensor (2 °C to 150 °C)

8.2.1.1 Design Requirements

Table 1. Design Parameters

| PARAMETER | VALUE |
|-------------------------------|----------|
| Accuracy at 25°C | ±0.5°C |
| Accuracy from –55 °C to 150°C | ±1°C |
| Temperature Slope | 10 mV/°C |

8.2.1.2 Detailed Design Procedure

Because the LM35 device is a simple temperature sensor that provides an analog output, design requirements related to layout are more important than electrical requirements. For a detailed description, refer to the [Layout](#).

8.2.1.3 Application Curve

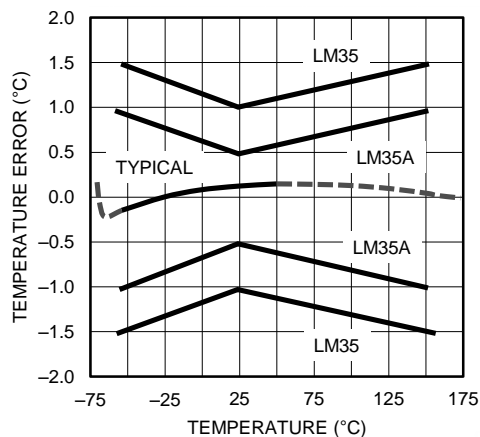


Figure 15. Accuracy vs Temperature (Ensured)

System Examples (continued)

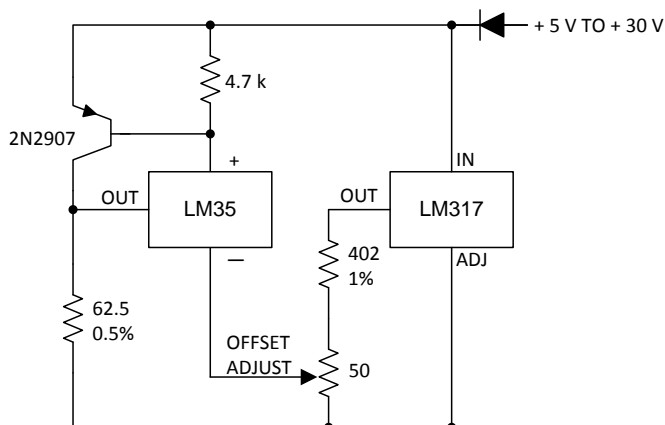


Figure 20. 4-To-20 mA Current Source (0°C to 100°C)

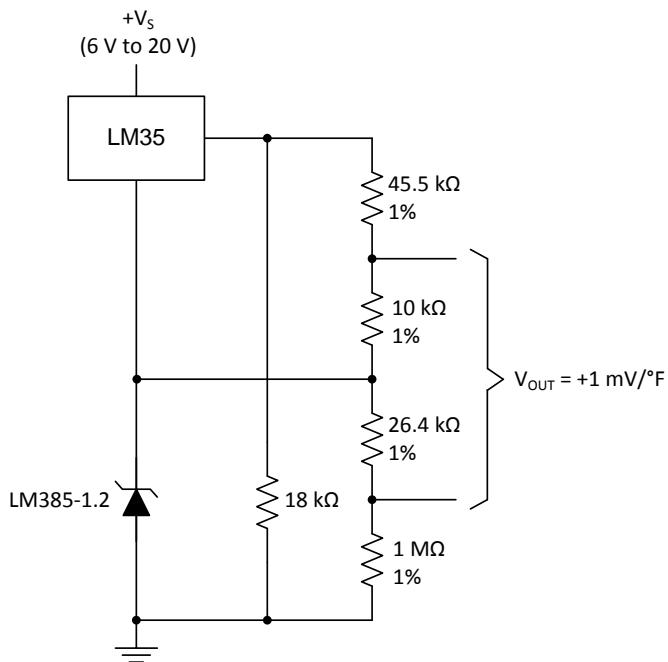


Figure 21. Fahrenheit Thermometer

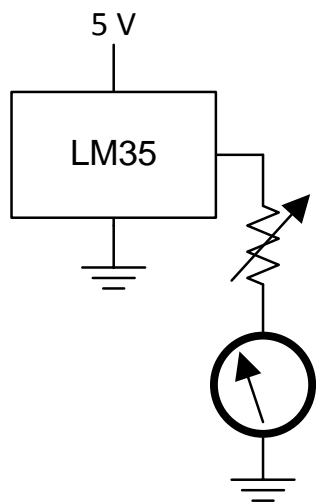


Figure 22. Centigrade Thermometer (Analog Meter)

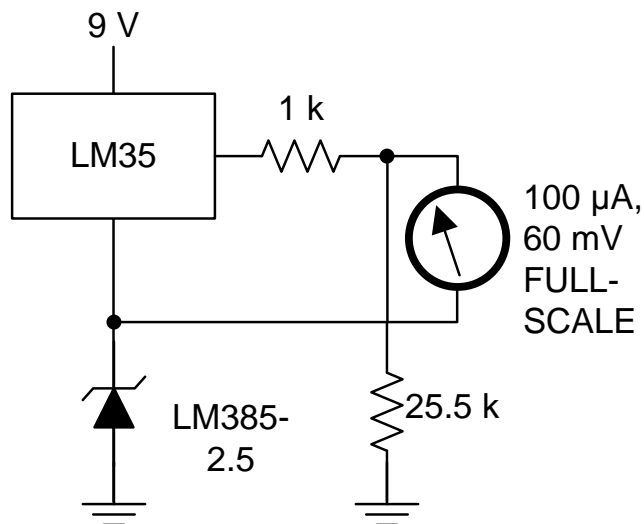


Figure 23. Fahrenheit Thermometer, Expanded Scale Thermometer (50°F to 80°F, for Example Shown)

9 Power Supply Recommendations

The LM35 device has a very wide 4-V to 30-V power supply voltage range, which makes it ideal for many applications. In noisy environments, TI recommends adding a 0.1 μF from V+ to GND to bypass the power supply voltage. Larger capacitances may be required and are dependent on the power-supply noise.

10 Layout

10.1 Layout Guidelines

The LM35 is easily applied in the same way as other integrated-circuit temperature sensors. Glue or cement the device to a surface and the temperature should be within about 0.01°C of the surface temperature.

The 0.01°C proximity presumes that the ambient air temperature is almost the same as the surface temperature. If the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature; this is especially true for the TO-92 plastic package. The copper leads in the TO-92 package are the principal thermal path to carry heat into the device, so its temperature might be closer to the air temperature than to the surface temperature.

Ensure that the wiring leaving the LM35 device is held at the same temperature as the surface of interest to minimize the temperature problem. The easiest fix is to cover up these wires with a bead of epoxy. The epoxy bead will ensure that the leads and wires are all at the same temperature as the surface, and that the temperature of the LM35 die is not affected by the air temperature.

The TO-46 metal package can also be soldered to a metal surface or pipe without damage. Of course, in that case the V- terminal of the circuit will be grounded to that metal. Alternatively, mount the LM35 inside a sealed-end metal tube, and then dip into a bath or screw into a threaded hole in a tank. As with any IC, the LM35 device and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. Printed-circuit coatings and varnishes such as a conformal coating and epoxy paints or dips are often used to insure that moisture cannot corrode the LM35 device or its connections.

These devices are sometimes soldered to a small light-weight heat fin to decrease the thermal time constant and speed up the response in slowly-moving air. On the other hand, a small thermal mass may be added to the sensor, to give the steadiest reading despite small deviations in the air temperature.

Table 2. Temperature Rise of LM35 Due To Self-heating (Thermal Resistance, $R_{\theta JA}$)

| | TO, no heat sink | TO ⁽¹⁾ , small heat fin | TO-92, no heat sink | TO-92 ⁽²⁾ , small heat fin | SOIC-8, no heat sink | SOIC-8 ⁽²⁾ , small heat fin | TO-220, no heat sink |
|----------------------------------------|------------------|------------------------------------|---------------------|---------------------------------------|----------------------|----------------------------------------|----------------------|
| Still air | 400°C/W | 100°C/W | 180°C/W | 140°C/W | 220°C/W | 110°C/W | 90°C/W |
| Moving air | 100°C/W | 40°C/W | 90°C/W | 70°C/W | 105°C/W | 90°C/W | 26°C/W |
| Still oil | 100°C/W | 40°C/W | 90°C/W | 70°C/W | — | — | — |
| Stirred oil | 50°C/W | 30°C/W | 45°C/W | 40°C/W | — | — | — |
| (Clamped to metal, Infinite heat sink) | (24°C/W) | | — | — | (55°C/W) | | — |

(1) Wakefield type 201, or 1-in disc of 0.02-in sheet brass, soldered to case, or similar.

(2) TO-92 and SOIC-8 packages glued and leads soldered to 1-in square of 1/16-in printed circuit board with 2-oz foil or similar.

11 Device and Documentation Support

11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document

11.2 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.3 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.4 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|----------------------|
| LM35AH | Active | Production | TO (NDV) 3 | 500 SMALL T&R | No | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35AH, LM35AH) |
| LM35AH.B | Active | Production | TO (NDV) 3 | 500 SMALL T&R | No | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35AH, LM35AH) |
| LM35AH/NOPB | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35AH, LM35AH) |
| LM35AH/NOPB.B | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35AH, LM35AH) |
| LM35CAH | Active | Production | TO (NDV) 3 | 500 OTHER | No | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CAH, LM35CAH) |
| LM35CAH.B | Active | Production | TO (NDV) 3 | 500 OTHER | No | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CAH, LM35CAH) |
| LM35CAH/NOPB | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CAH, LM35CAH) |
| LM35CAH/NOPB.B | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CAH, LM35CAH) |
| LM35CAZ/LFT4 | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 CAZ |
| LM35CAZ/LFT4.B | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 CAZ |
| LM35CAZ/NOPB | Active | Production | TO-92 (LP) 3 | 1800 BULK | Yes | SN | N/A for Pkg Type | -40 to 110 | LM35 CAZ |
| LM35CAZ/NOPB.B | Active | Production | TO-92 (LP) 3 | 1800 BULK | Yes | SN | N/A for Pkg Type | -40 to 110 | LM35 CAZ |
| LM35CH | Active | Production | TO (NDV) 3 | 500 OTHER | No | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CH, LM35CH) |
| LM35CH.B | Active | Production | TO (NDV) 3 | 500 OTHER | No | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CH, LM35CH) |
| LM35CH/NOPB | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CH, LM35CH) |
| LM35CH/NOPB.B | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CH, LM35CH) |
| LM35CZ/LFT1 | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 CZ |
| LM35CZ/LFT1.B | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 CZ |
| LM35CZ/NOPB | Active | Production | TO-92 (LP) 3 | 1800 BULK | Yes | SN | N/A for Pkg Type | -40 to 110 | LM35 CZ |
| LM35CZ/NOPB.B | Active | Production | TO-92 (LP) 3 | 1800 BULK | Yes | SN | N/A for Pkg Type | -40 to 110 | LM35 CZ |

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| LM35DH | Active | Production | TO (NDV) 3 | 1000 SMALL T&R | No | Call TI | Level-1-NA-UNLIM | 0 to 70 | (LM35DH, LM35DH) |
| LM35DH.B | Active | Production | TO (NDV) 3 | 1000 SMALL T&R | No | Call TI | Level-1-NA-UNLIM | 0 to 70 | (LM35DH, LM35DH) |
| LM35DH/NOPB | Active | Production | TO (NDV) 3 | 1000 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | 0 to 70 | (LM35DH, LM35DH) |
| LM35DH/NOPB.B | Active | Production | TO (NDV) 3 | 1000 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | 0 to 70 | (LM35DH, LM35DH) |
| LM35DMX | NRND | Production | SOIC (D) 8 | 2500 LARGE T&R | No | SNPB | Level-1-235C-UNLIM | 0 to 100 | LM35D M |
| LM35DMX.B | NRND | Production | SOIC (D) 8 | 2500 LARGE T&R | No | SNPB | Level-1-235C-UNLIM | 0 to 100 | LM35D M |
| LM35DMX/NOPB | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 100 | LM35D M |
| LM35DMX/NOPB.B | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 100 | LM35D M |
| LM35DT | NRND | Production | TO-220 (NEB) 3 | 45 TUBE | - | Call TI | Call TI | 0 to 100 | LM35DT |
| LM35DT.B | NRND | Production | TO-220 (NEB) 3 | 45 TUBE | - | Call TI | Call TI | 0 to 100 | LM35DT |
| LM35DT/NOPB | Active | Production | TO-220 (NEB) 3 | 45 TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 100 | LM35DT |
| LM35DT/NOPB.B | Active | Production | TO-220 (NEB) 3 | 45 TUBE | Yes | SN | Level-1-NA-UNLIM | 0 to 100 | LM35DT |
| LM35DZ/LFT1 | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 DZ |
| LM35DZ/LFT1.B | Active | Production | TO-92 (LP) 3 | 2000 LARGE T&R | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 DZ |
| LM35DZ/LFT4 | Active | Production | TO-92 (LP) 3 | 2000 AMMO | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 DZ |
| LM35DZ/LFT4.B | Active | Production | TO-92 (LP) 3 | 2000 AMMO | Yes | SN | N/A for Pkg Type | -55 to 150 | LM35 DZ |
| LM35DZ/NOPB | Active | Production | TO-92 (LP) 3 | 1800 BULK | Yes | SN | N/A for Pkg Type | 0 to 100 | LM35 DZ |
| LM35DZ/NOPB.B | Active | Production | TO-92 (LP) 3 | 1800 BULK | Yes | SN | N/A for Pkg Type | 0 to 100 | LM35 DZ |
| LM35H | Active | Production | TO (NDV) 3 | 500 SMALL T&R | No | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35H, LM35H) |
| LM35H.B | Active | Production | TO (NDV) 3 | 500 SMALL T&R | No | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35H, LM35H) |
| LM35H/NOPB | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35H, LM35H) |
| LM35H/NOPB.B | Active | Production | TO (NDV) 3 | 500 SMALL T&R | Yes | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35H, LM35H) |

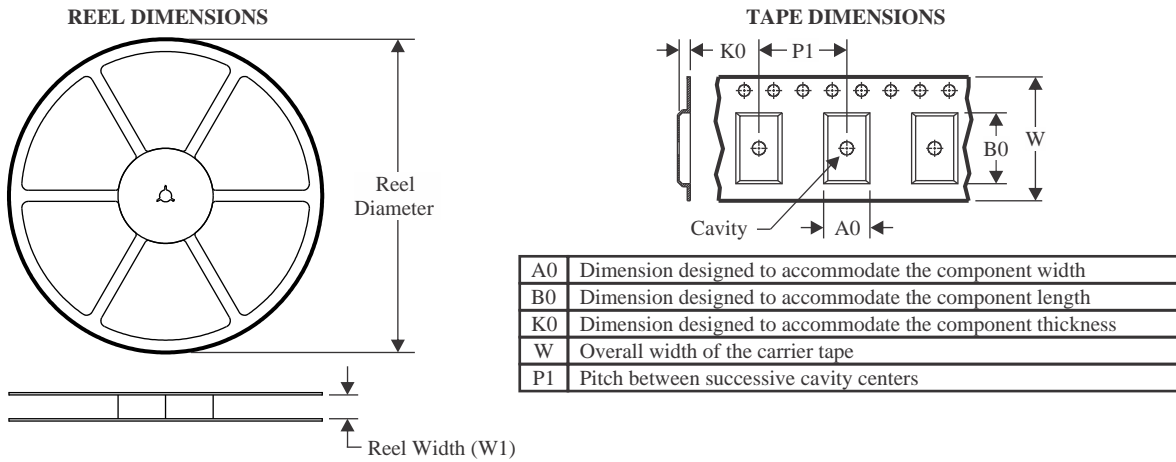
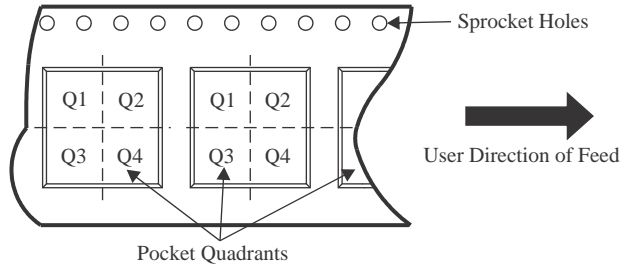
⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

- (2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.
- (3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.
- (4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.
- (5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.
- (6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

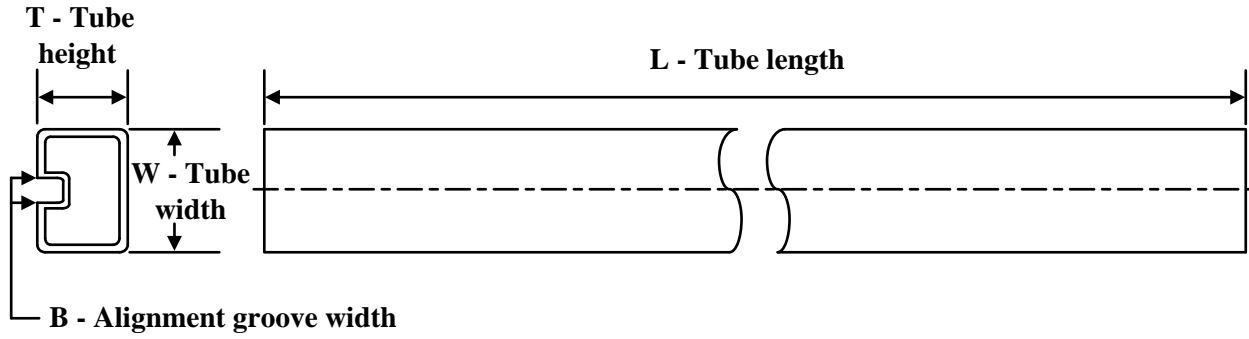
| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM35DMX/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM35DMX/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |

TUBE


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|---------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LM35DT/NOPB | NEB | TO-220 | 3 | 45 | 502 | 33 | 6985 | 4.06 |
| LM35DT/NOPB.B | NEB | TO-220 | 3 | 45 | 502 | 33 | 6985 | 4.06 |

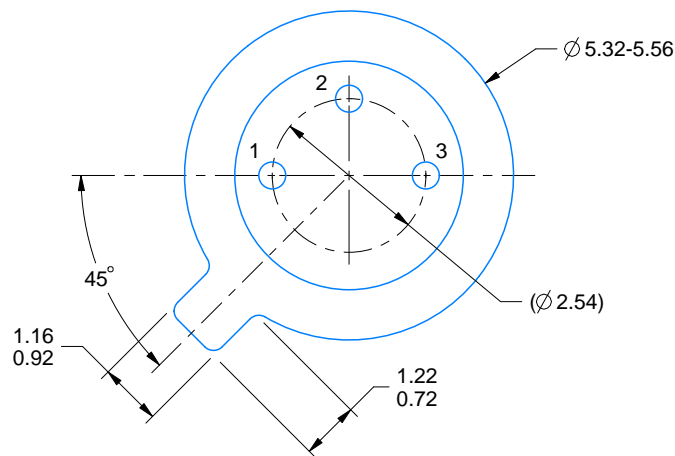
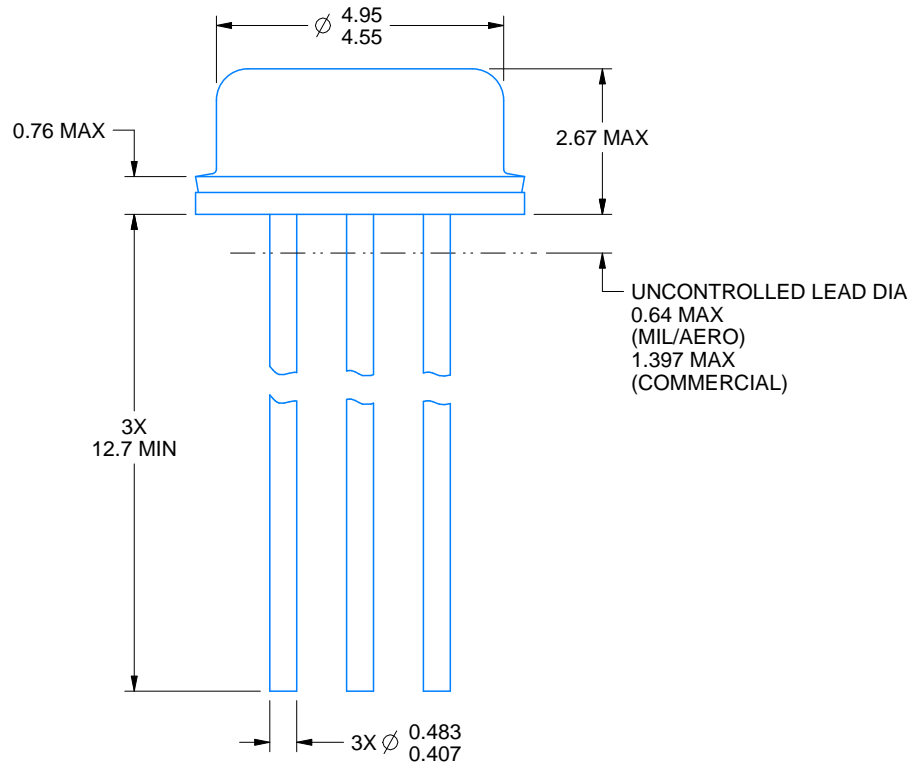
NDV0003H



PACKAGE OUTLINE

TO-CAN - 2.67 mm max height

TRANSISTOR OUTLINE



4219876/B 09/2024

NOTES:

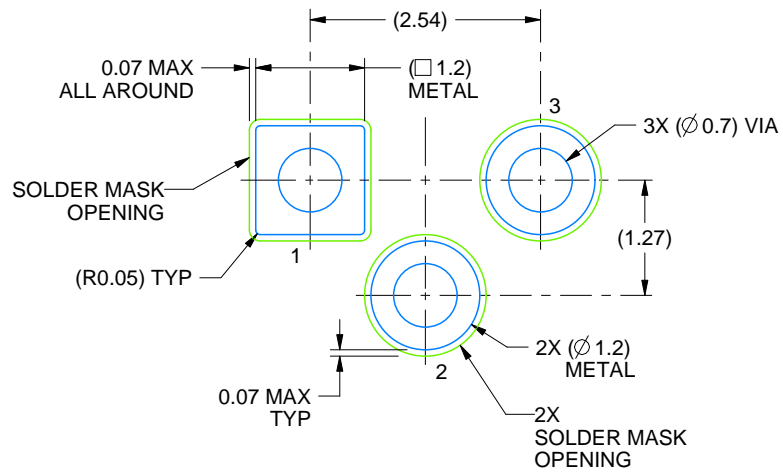
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-46.

EXAMPLE BOARD LAYOUT

NDV0003H

TO-CAN - 2.67 mm max height

TRANSISTOR OUTLINE



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE:12X

4219876/B 09/2024



D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

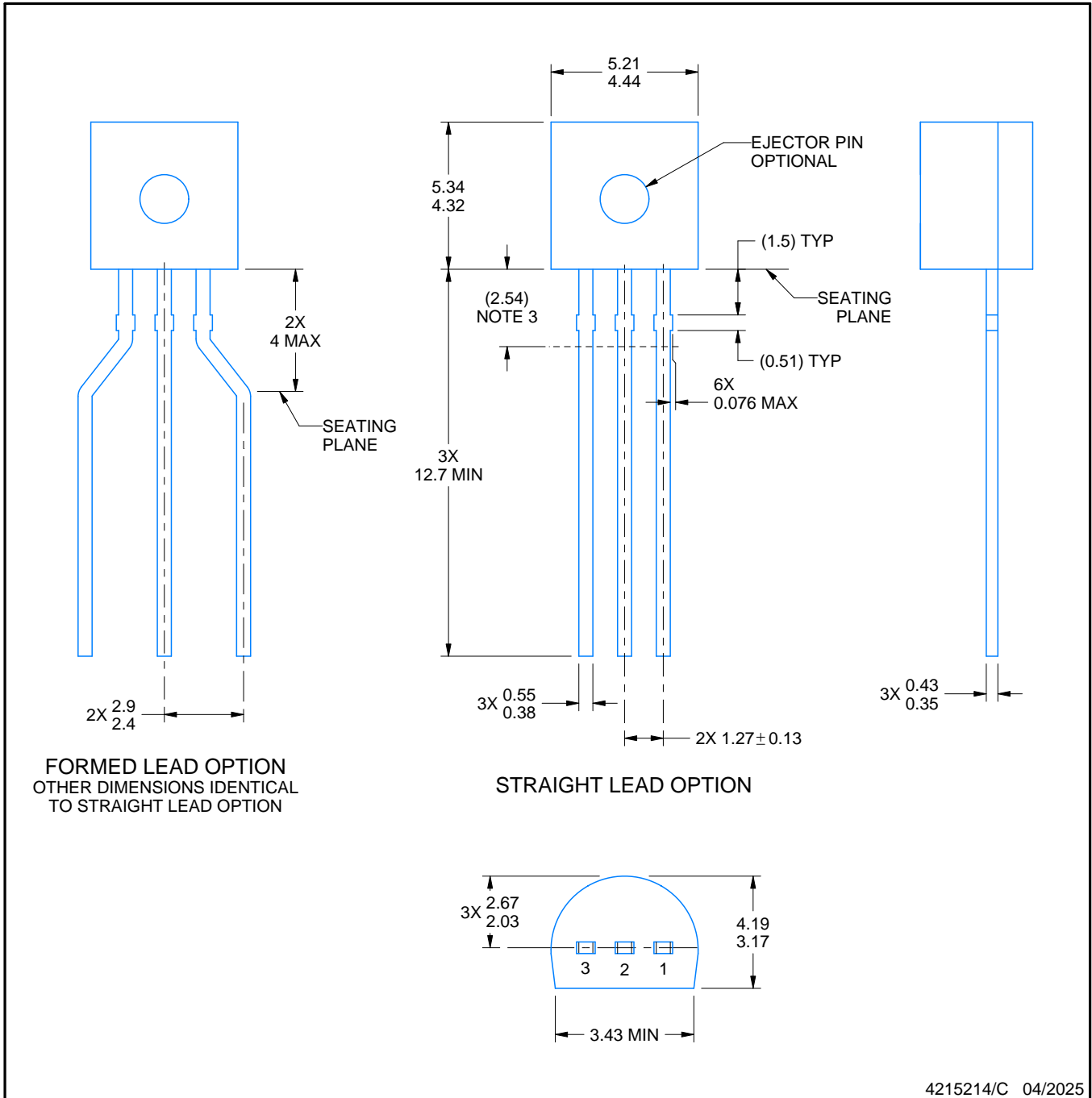
LP0003A



PACKAGE OUTLINE

TO-92 - 5.34 mm max height

TO-92



4215214/C 04/2025

NOTES:

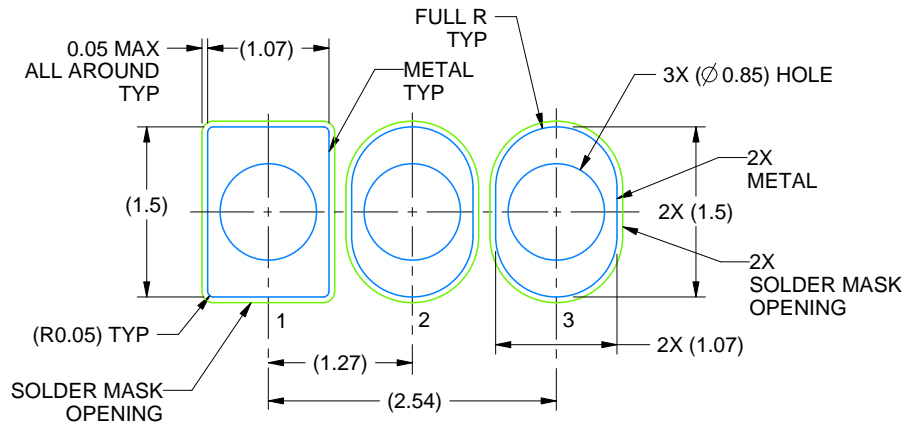
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
 - a. Straight lead option available in bulk pack only.
 - b. Formed lead option available in tape and reel or ammo pack.
 - c. Specific products can be offered in limited combinations of shipping medium and lead options.
 - d. Consult product folder for more information on available options.

EXAMPLE BOARD LAYOUT

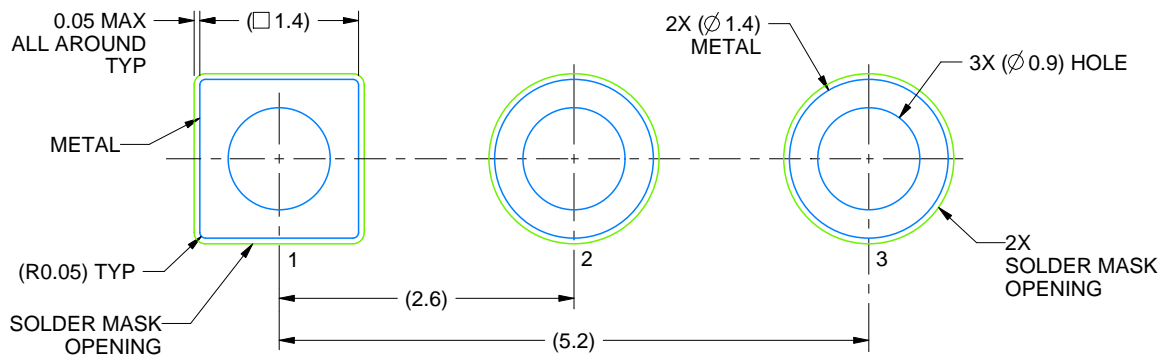
LP0003A

TO-92 - 5.34 mm max height

TO-92



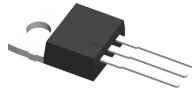
LAND PATTERN EXAMPLE
STRAIGHT LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X



LAND PATTERN EXAMPLE
FORMED LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X

4215214/C 04/2025

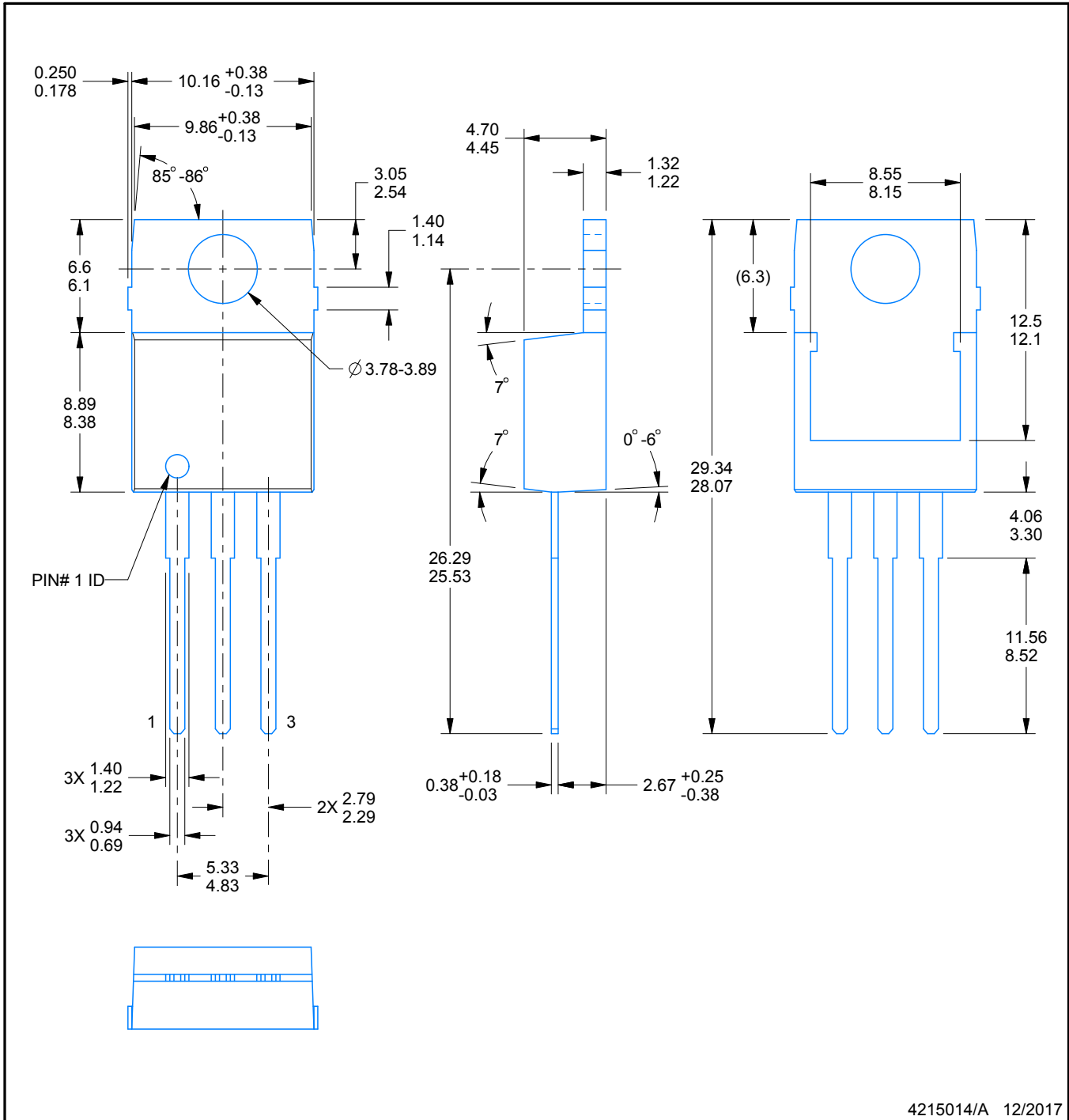
NEB0003F



PACKAGE OUTLINE

TO-220 - 19.65 mm max height

TRANSISTOR OUTLINE



4215014/A 12/2017

NOTES:

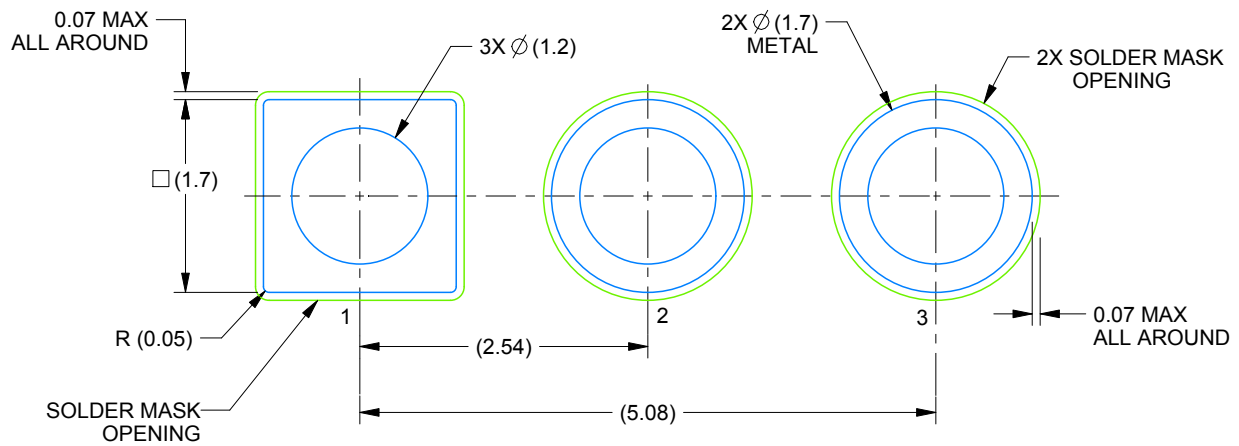
1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-220.

EXAMPLE BOARD LAYOUT

NEB0003F

TO-220 - 19.65 mm max height

TRANSISTOR OUTLINE



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE:15X

4215014/A 12/2017

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