

LM35 高精度摄氏温度传感器

1 特性

- 直接以摄氏温度（摄氏度）进行校准
- 线性 $+10\text{mV}/^{\circ}\text{C}$ 比例因子
- 0.5°C 的确保精度（ 25°C 时）
- 额定温度范围为 -55°C 至 150°C
- 适用于远程应用
- 晶圆级修整实现低成本
- 工作电压范围 4V 至 30V
- 电流漏极小于 $60\mu\text{A}$
- 低自发热，处于静止的空气中时为 0.08°C
- 非线性典型值仅 $\pm 1/4^{\circ}\text{C}$
- 低阻抗输出， 1mA 负载时为 0.1Ω

2 应用

- 电源
- 电池管理
- HVAC
- 电器

3 说明

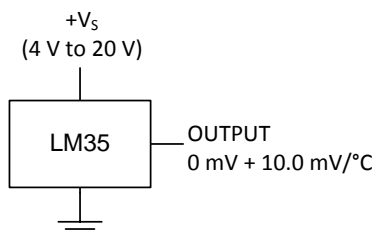
LM35 系列产品是高精度集成电路温度器件，其输出电压与摄氏温度成线性正比关系。相比于以开尔文温度校准的线性温度传感器，LM35 器件的优势在于使用者无需在输出电压中减去一个较大的恒定电压值即可便捷地实现摄氏度调节。LM35 器件无需进行任何外部校准或修整，可在室温下提供 $\pm 1/4^{\circ}\text{C}$ 的典型精度，而在 -55°C 至 $+150^{\circ}\text{C}$ 的完整温度范围内提供 $\pm 3/4^{\circ}\text{C}$ 的精度。晶圆级的修正和校准可确保更低的成本。LM35 器件具有低输出阻抗、线性输出和高精度内在校准功能，这些特性使得连接读取或控制电路变得尤为简单。此器件可使用单电源或正负电源供电。因为 LM35 器件仅需从电源中消耗 $60\mu\text{A}$ 的电流，所以处于静止的空气中时具有不到 0.1°C 的极低自发热。LM35 器件额定工作温度范围为 -55°C 至 150°C ，LM35C 器件额定工作温度范围 -40°C 至 110°C （ -10° 时精度更高）。LM35 系列器件采用密封 TO 晶体管封装，LM35C、LM35CA 和 LM35D 器件采用塑料 TO-92 晶体管封装。LM35D 器件采用 8 引线表面贴装小外形封装和塑料 TO-220 封装。

器件信息⁽¹⁾

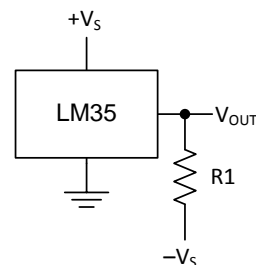
| 器件型号 | 封装 | 封装尺寸（标称值） |
|------|------------|--------------------|
| LM35 | TO-CAN (3) | 4.699mm x 4.699mm |
| | TO-92 (3) | 4.30mm x 4.30mm |
| | SOIC (8) | 4.90mm x 3.91mm |
| | TO-220 (3) | 14.986mm x 10.16mm |

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。

基本摄氏温度传感器
(2°C 至 150°C)



全范围摄氏温度传感器



选择 $R_1 = -V_S/50\mu\text{A}$
 150°C 时, $V_{\text{OUT}} = 1500\text{mV}$
 25°C 时, $V_{\text{OUT}} = 250\text{mV}$
 -55°C 时, $V_{\text{OUT}} = -550\text{mV}$



目录

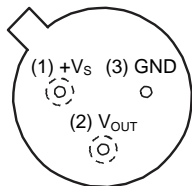
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4 修订历史记录

| | | |
|---|---|-------------|
| 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 |
| • | 已添加 引脚配置和功能 部分、ESD 额定值表、特性 说明 部分、器件功能模式、应用和实施 部分、电源相关建议 部分、布局 部分、器件和文档支持 部分以及机械、封装和可订购信息 部分 | 1 |
| Changes from Revision C (July 2013) to Revision D | | Page |
| • | 已更改 将 W 更改为 Ω 添加了 | 1 |
| • | Changed W to Ω in <i>Abs Max</i> tablenote. | 4 |

5 Pin Configuration and Functions

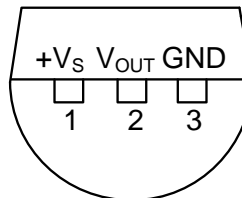
**NDV Package
3-Pin TO-CAN
(Top View)**



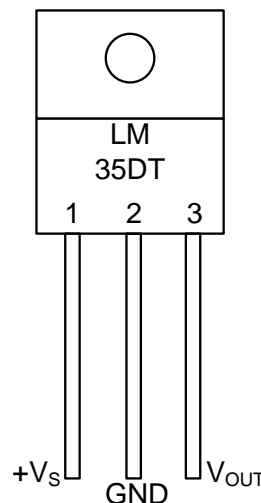
Case is connected to negative pin (GND)

Refer the second NDV0003H page for reference

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



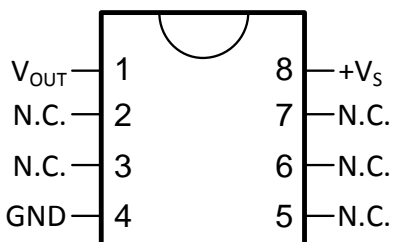
**NEB Package
3-Pin TO-220
(Top View)**



Tab is connected to the negative pin (GND).

NOTE: The LM35DT pinout is different than the discontinued LM35DP

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



N.C. = No connection

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 | |
| $R_{\theta JA}$ Junction-to-ambient thermal resistance | 400 | 180 | 220 | 90 | °C/W |
| $R_{\theta JC(top)}$ 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⁾ | | | | | | ± 1 |
| | | 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 $10\text{ mV}/^{\circ}\text{C}$ times the case temperature of the device, at specified conditions of voltage, current, and temperature (expressed in $^{\circ}\text{C}$).
- (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°C | | 56 | | 56 | | | μA | |
| | | Tested Limit ⁽²⁾ | | | | 67 | | | |
| | | Design Limit ⁽³⁾ | | | | | 67 | | |
| | $V_S = 5\text{ V}$, $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ | | | 105 | | 91 | | | |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | 131 | | 114 | | |
| | $V_S = 30\text{ V}$, 25°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⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | 133 | | 116 | | |
| 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⁾ | | | 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⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | 2 | | 2 | | |
| 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⁾ | | | | | ± 1 | | |
| | $T_A = -10^{\circ}\text{C}$ | | | ± 0.5 | | | ± 0.5 | | |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | | ± 1.5 | | |
| | $T_A = T_{\text{MAX}}$ | | | ± 0.8 | | ± 1.5 | | | ± 0.8 |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | | | ± 1.5 | | |
| | $T_A = T_{\text{MIN}}$ | | | ± 0.8 | | | | | ± 0.8 |
| | | Tested Limit ⁽²⁾ | | | | | | | |
| | | Design Limit ⁽³⁾ | | | ± 1.5 | | | | ± 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 | | | | ± 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 | | ± 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 | | ± 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

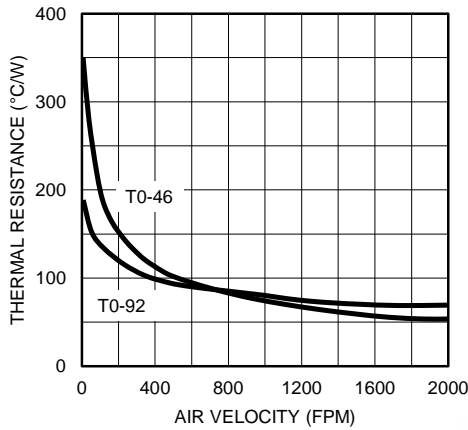


Figure 1. Thermal Resistance Junction To Air



Figure 2. Thermal Time Constant

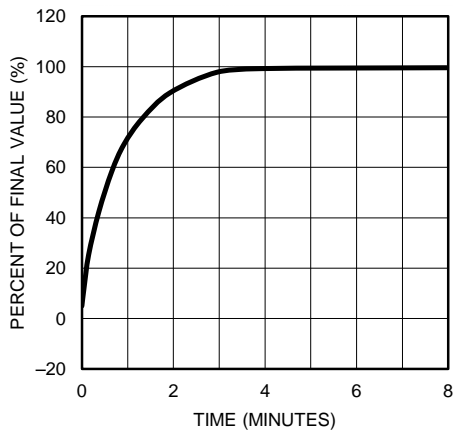


Figure 3. Thermal Response In Still Air

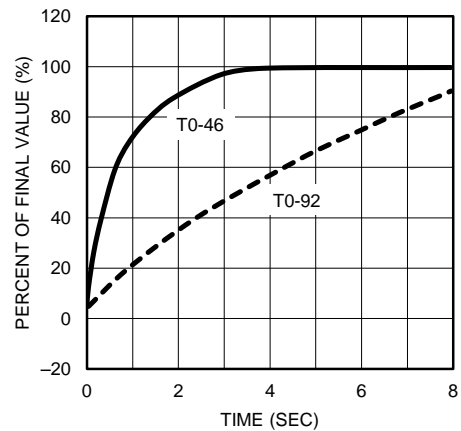


Figure 4. Thermal Response In Stirred Oil Bath

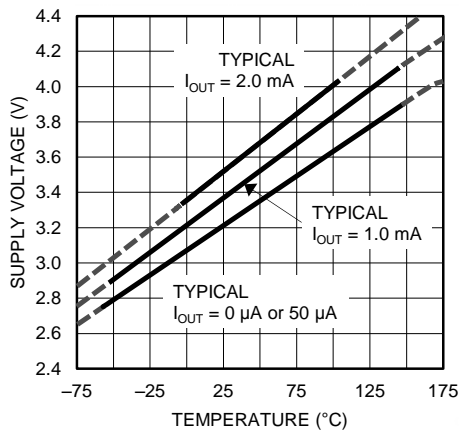


Figure 5. Minimum Supply Voltage vs Temperature

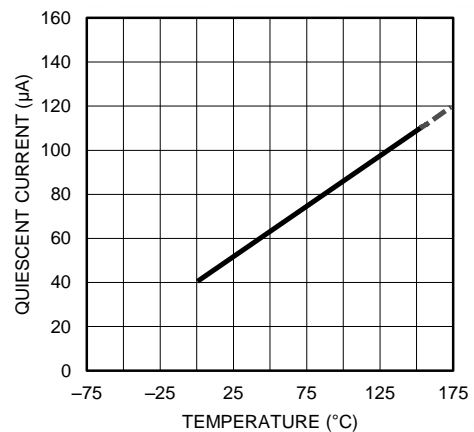


Figure 6. Quiescent Current vs Temperature (in Circuit of Figure 14)

Typical Characteristics (continued)

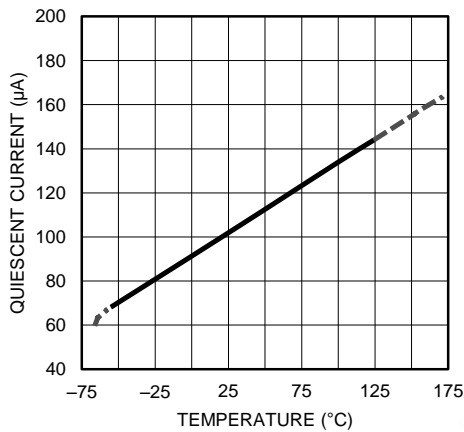


Figure 7. Quiescent Current vs Temperature (in Circuit of Full-Range Centigrade Temperature Sensor)



Figure 8. Accuracy vs Temperature (Ensured)

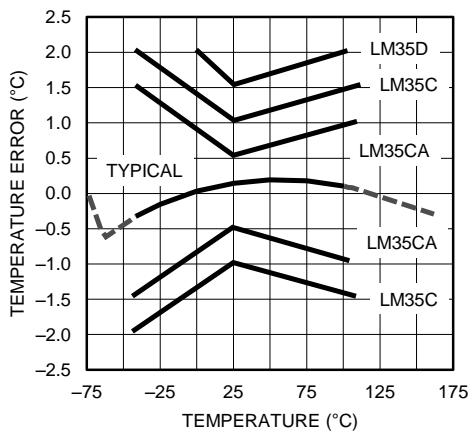


Figure 9. Accuracy vs Temperature (Ensured)



Figure 10. Noise Voltage



Figure 11. Start-Up Response

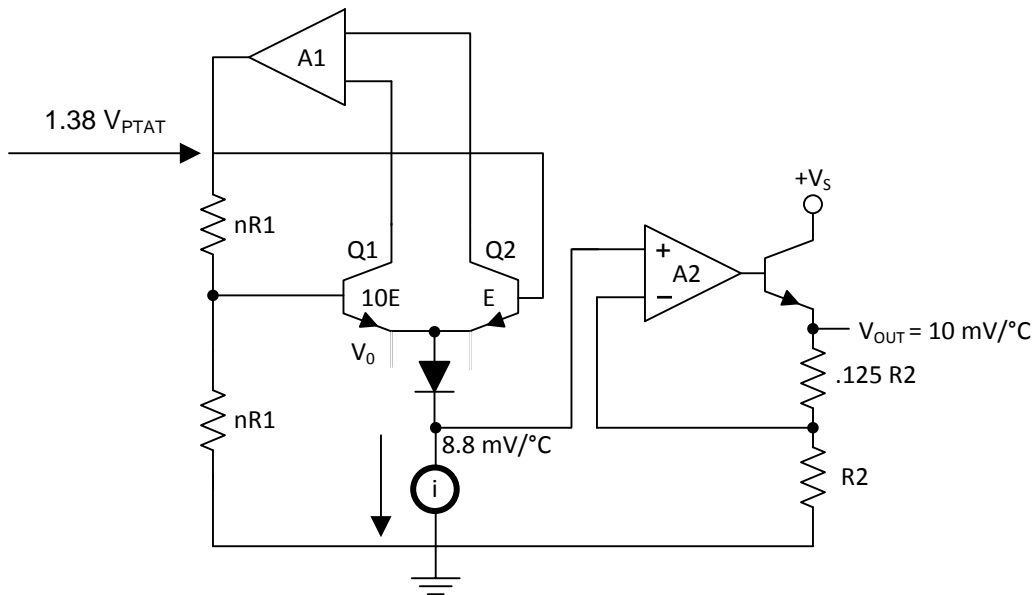
7 Detailed Description

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.

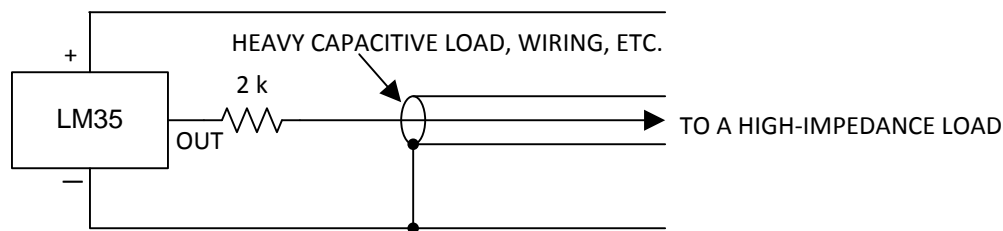


Figure 12. LM35 with Decoupling from Capacitive Load

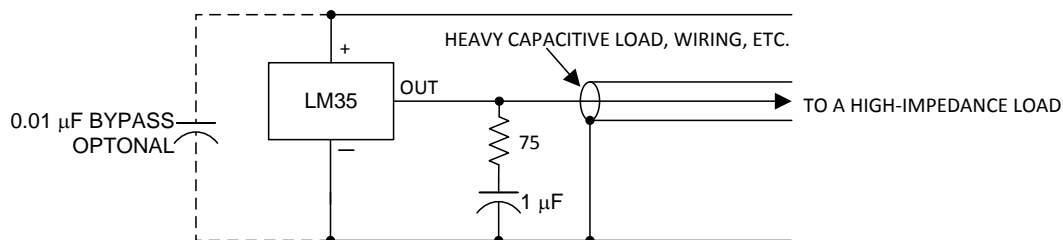


Figure 13. LM35 with R-C Damper

8.2 Typical Application

8.2.1 Basic Centigrade Temperature Sensor

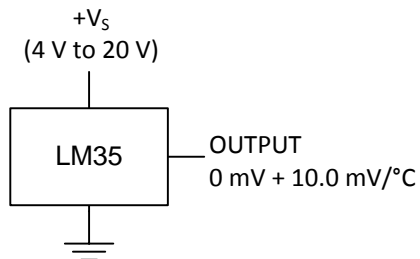


Figure 14. Basic Centigrade Temperature Sensor (2 °C to 150 °C)

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)

8.3 System Examples

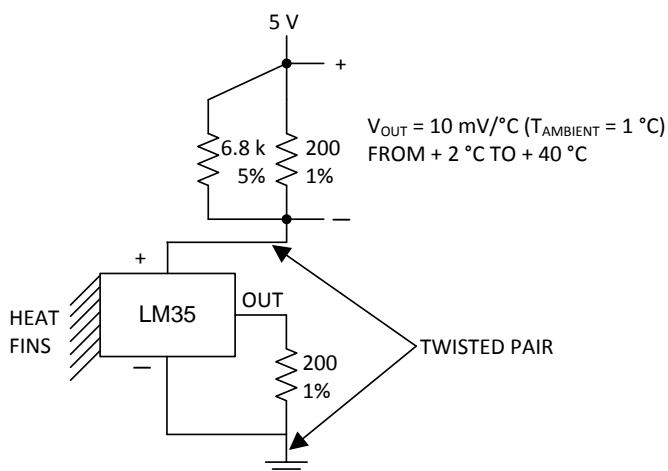


Figure 16. Two-Wire Remote Temperature Sensor (Grounded Sensor)

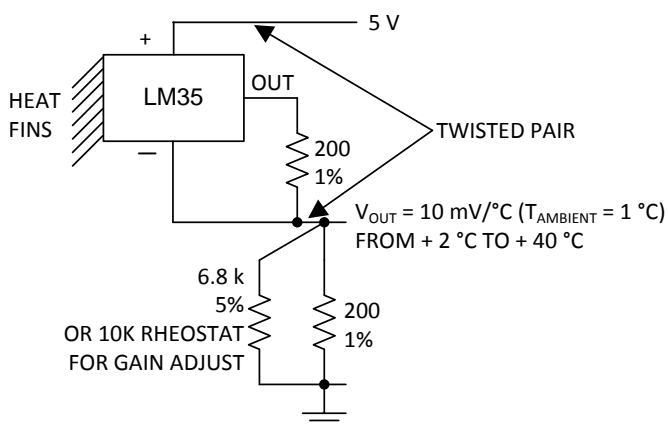


Figure 17. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

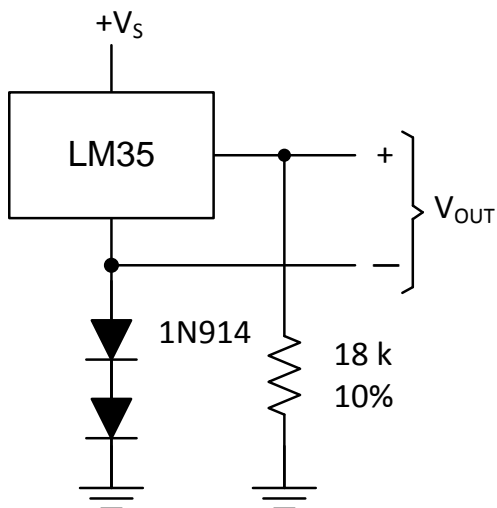


Figure 18. Temperature Sensor, Single Supply (-55° to +150°C)

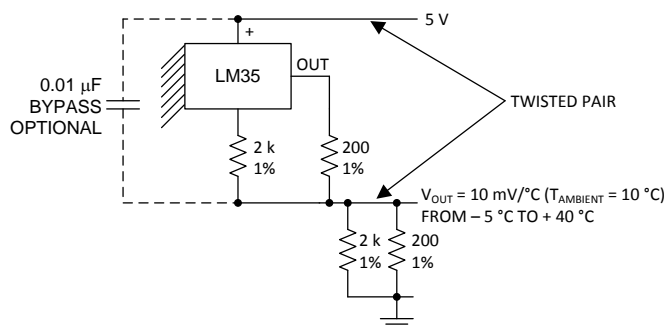


Figure 19. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

System Examples (continued)

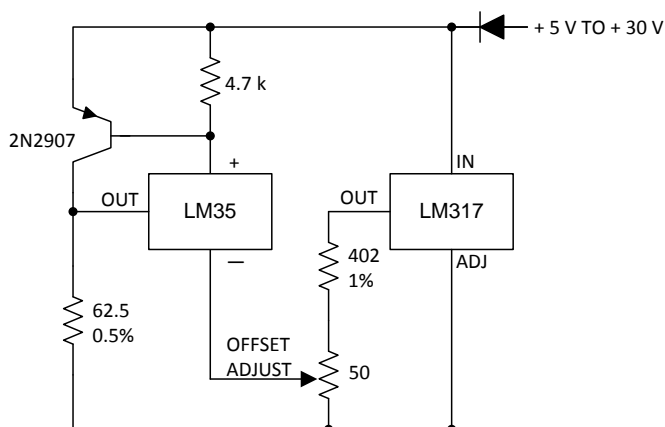


Figure 20. 4-To-20 mA Current Source (0°C to 100°C)

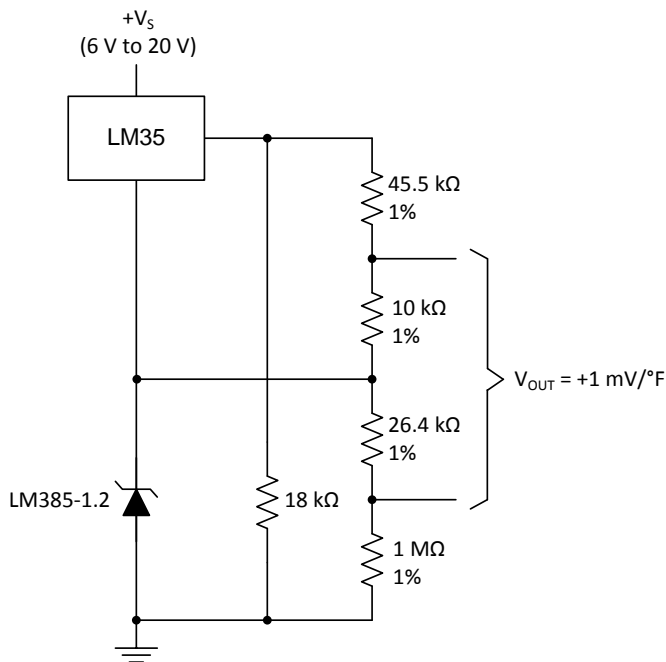


Figure 21. Fahrenheit Thermometer

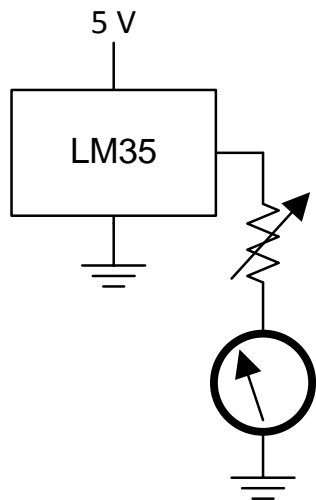


Figure 22. Centigrade Thermometer (Analog Meter)

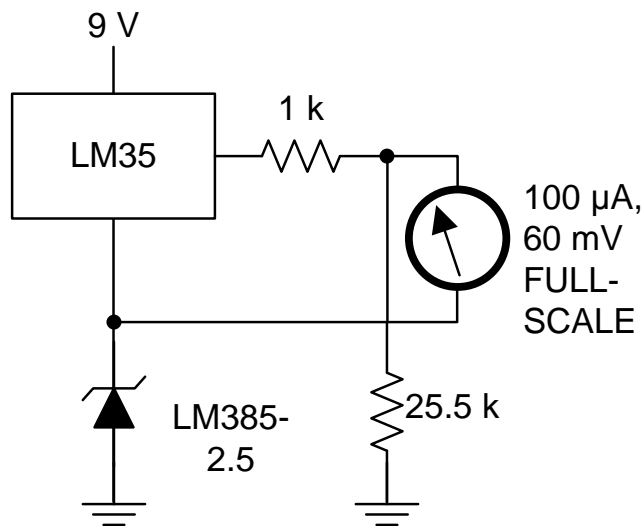
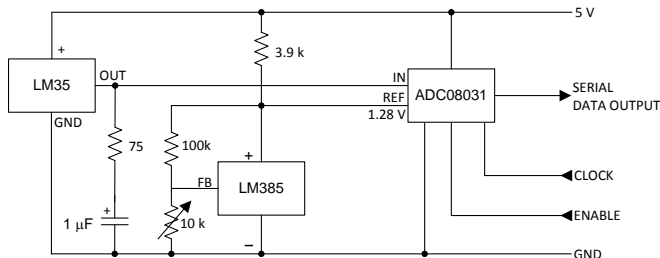
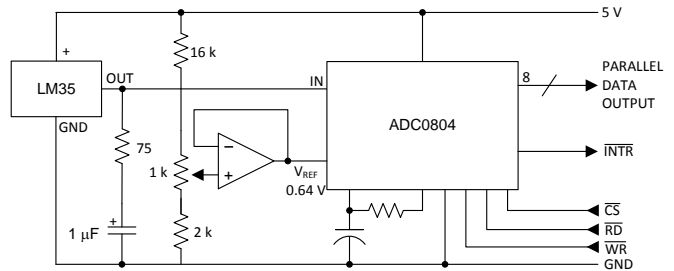


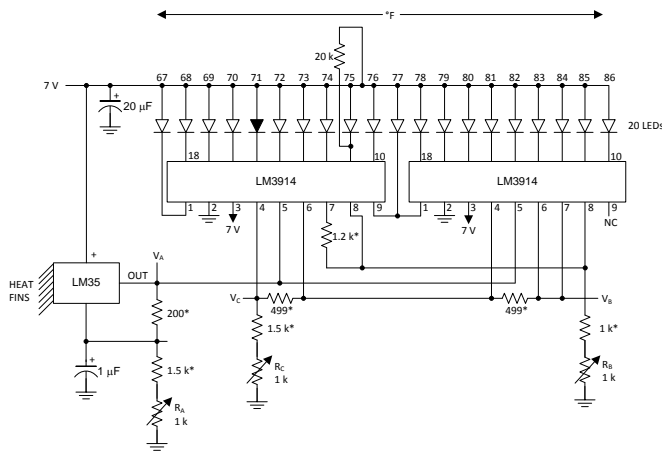
Figure 23. Fahrenheit Thermometer, Expanded Scale Thermometer (50°F to 80°F, for Example Shown)

System Examples (continued)


**Figure 24. Temperature to Digital Converter
(Serial Output)
(128°C Full Scale)**



**Figure 25. Temperature to Digital Converter
(Parallel TRI-STATE Outputs for Standard Data Bus
to μ P Interface)
(128°C Full Scale)**



*=1% or 2% film resistor

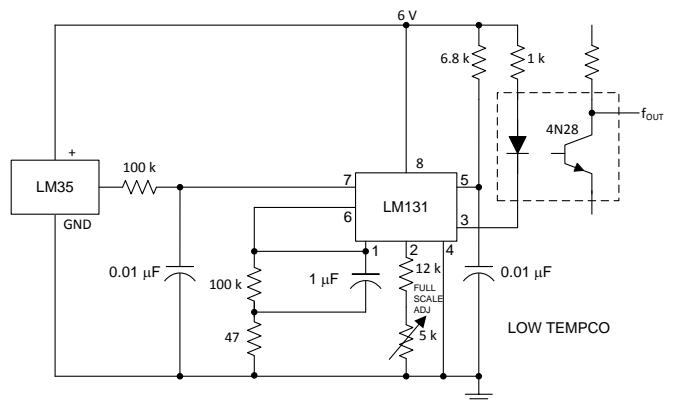
Trim R_B for $V_B = 3.075$ V

Trim R_C for $V_C = 1.955$ V

Trim R_A for $V_A = 0.075$ V + 100 mV/°C $\times T_{\text{ambient}}$

Example, $V_A = 2.275$ V at 22°C

**Figure 26. Bar-Graph Temperature Display
(Dot Mode)**



**Figure 27. LM35 With Voltage-To-Frequency
Converter and Isolated Output
(2°C to 150°C; 20 to 1500 Hz)**

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.

10.2 Layout Example

○ VIA to ground plane

○ VIA to power plane

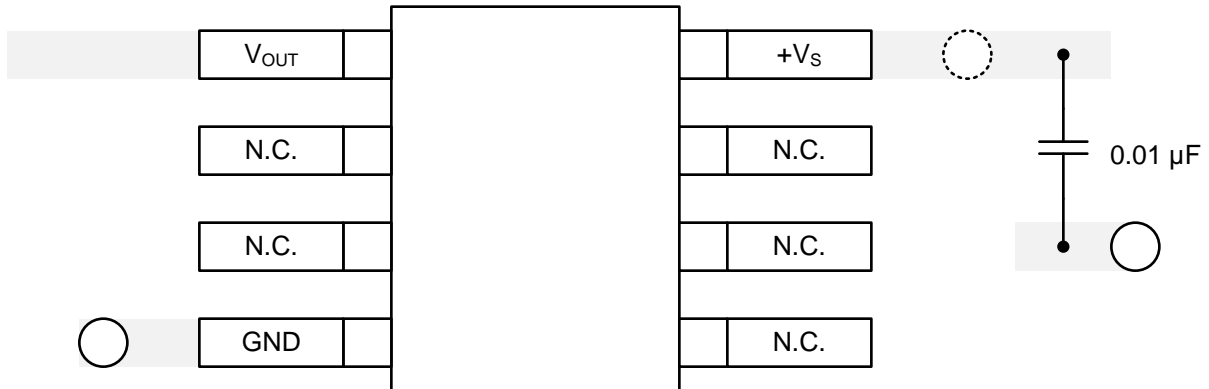


Figure 28. Layout Example

11 器件和文档支持

11.1 接收文档更新通知

要接收文档更新通知，请导航至TI.com 上的器件产品文件夹。点击右上角的提醒我 (*Alert me*)注册后，即可每周定期收到已更改的产品信息。有关更改的详细信息，请查阅已修订文档中包含的修订历史记录

11.2 社区资源

下列链接提供到 TI 社区资源的连接。链接的内容由各个分销商“按照原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

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设计支持 *TI 参考设计支持* 可帮助您快速查找有帮助的 E2E 论坛、设计支持工具以及技术支持的联系信息。

11.3 商标

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All other trademarks are the property of their respective owners.

11.4 静电放电警告



这些装置包含有限的内置 ESD 保护。存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

11.5 Glossary

SLYZ022 — *TI Glossary*.

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

12 机械、封装和可订购信息

以下页面包含机械、封装和可订购信息。这些信息是指定器件的最新可用数据。数据如有变更，恕不另行通知和修订此文档。如欲获取此数据表的浏览器版本，请参阅左侧的导航。

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM35AH | ACTIVE | TO | NDV | 3 | 500 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35AH, LM35AH) | Samples |
| LM35AH/NOPB | ACTIVE | TO | NDV | 3 | 500 | RoHS & Green | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35AH, LM35AH) | Samples |
| LM35CAH | ACTIVE | TO | NDV | 3 | 500 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CAH, LM35CAH) | Samples |
| LM35CAH/NOPB | ACTIVE | TO | NDV | 3 | 500 | RoHS & Green | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CAH, LM35CAH) | Samples |
| LM35CAZ/LFT4 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | SN | N / A for Pkg Type | | LM35 CAZ | Samples |
| LM35CAZ/NOPB | ACTIVE | TO-92 | LP | 3 | 1800 | RoHS & Green | SN | N / A for Pkg Type | -40 to 110 | LM35 CAZ | Samples |
| LM35CH | ACTIVE | TO | NDV | 3 | 500 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CH, LM35CH) | Samples |
| LM35CH/NOPB | ACTIVE | TO | NDV | 3 | 500 | RoHS & Green | Call TI | Level-1-NA-UNLIM | -40 to 110 | (LM35CH, LM35CH) | Samples |
| LM35CZ/LFT1 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | SN | N / A for Pkg Type | | LM35 CZ | Samples |
| LM35CZ/NOPB | ACTIVE | TO-92 | LP | 3 | 1800 | RoHS & Green | SN | N / A for Pkg Type | -40 to 110 | LM35 CZ | Samples |
| LM35DH | ACTIVE | TO | NDV | 3 | 1000 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | 0 to 70 | (LM35DH, LM35DH) | Samples |
| LM35DH/NOPB | ACTIVE | TO | NDV | 3 | 1000 | RoHS & Green | Call TI | Level-1-NA-UNLIM | 0 to 70 | (LM35DH, LM35DH) | Samples |
| LM35DM | NRND | SOIC | D | 8 | 95 | Non-RoHS & Green | Call TI | Level-1-235C-UNLIM | 0 to 100 | LM35D M | |
| LM35DMX | NRND | SOIC | D | 8 | 2500 | Non-RoHS & Green | Call TI | Level-1-235C-UNLIM | 0 to 100 | LM35D M | |
| LM35DMX/NOPB | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | 0 to 100 | LM35D M | Samples |
| LM35DT | NRND | TO-220 | NEB | 3 | 45 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | 0 to 100 | LM35DT | |
| LM35DT/NOPB | ACTIVE | TO-220 | NEB | 3 | 45 | RoHS & Green | SN | Level-1-NA-UNLIM | 0 to 100 | LM35DT | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|---------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM35DZ/LFT1 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | SN | N / A for Pkg Type | | LM35 DZ | Samples |
| LM35DZ/LFT4 | ACTIVE | TO-92 | LP | 3 | 2000 | RoHS & Green | SN | N / A for Pkg Type | | LM35 DZ | Samples |
| LM35DZ/NOPB | ACTIVE | TO-92 | LP | 3 | 1800 | RoHS & Green | SN | N / A for Pkg Type | 0 to 100 | LM35 DZ | Samples |
| LM35H | ACTIVE | TO | NDV | 3 | 500 | Non-RoHS & Green | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35H, LM35H) | Samples |
| LM35H/NOPB | ACTIVE | TO | NDV | 3 | 500 | RoHS & Green | Call TI | Level-1-NA-UNLIM | -55 to 150 | (LM35H, LM35H) | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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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 | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| 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 | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| 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) |
|-------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LM35DM | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM35DM | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM35DT | NEB | TO-220 | 3 | 45 | 502 | 33 | 6985 | 4.06 |
| LM35DT | NEB | TO-220 | 3 | 45 | 502 | 33 | 6985 | 4.06 |
| LM35DT/NOPB | NEB | TO-220 | 3 | 45 | 502 | 33 | 6985 | 4.06 |



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.

GENERIC PACKAGE VIEW

LP 3

TO-92 - 5.34 mm max height

TRANSISTOR OUTLINE



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4040001-2/F

LP0003A



PACKAGE OUTLINE

TO-92 - 5.34 mm max height

TO-92



4215214/B 04/2017

NOTES:

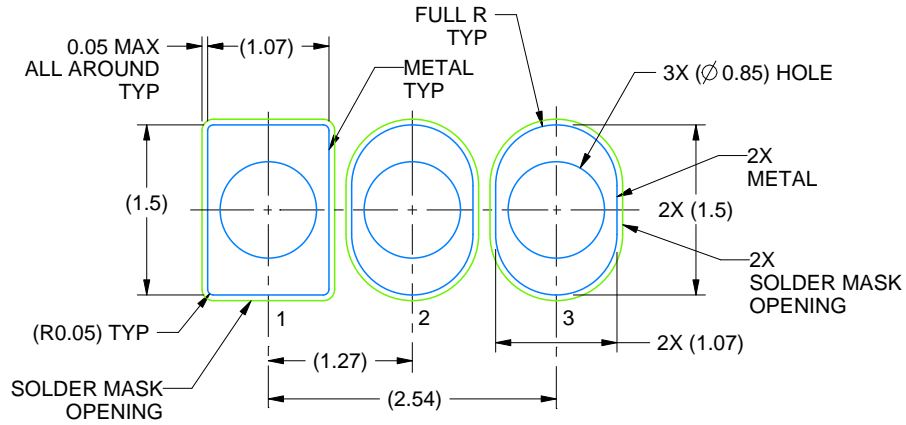
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping 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

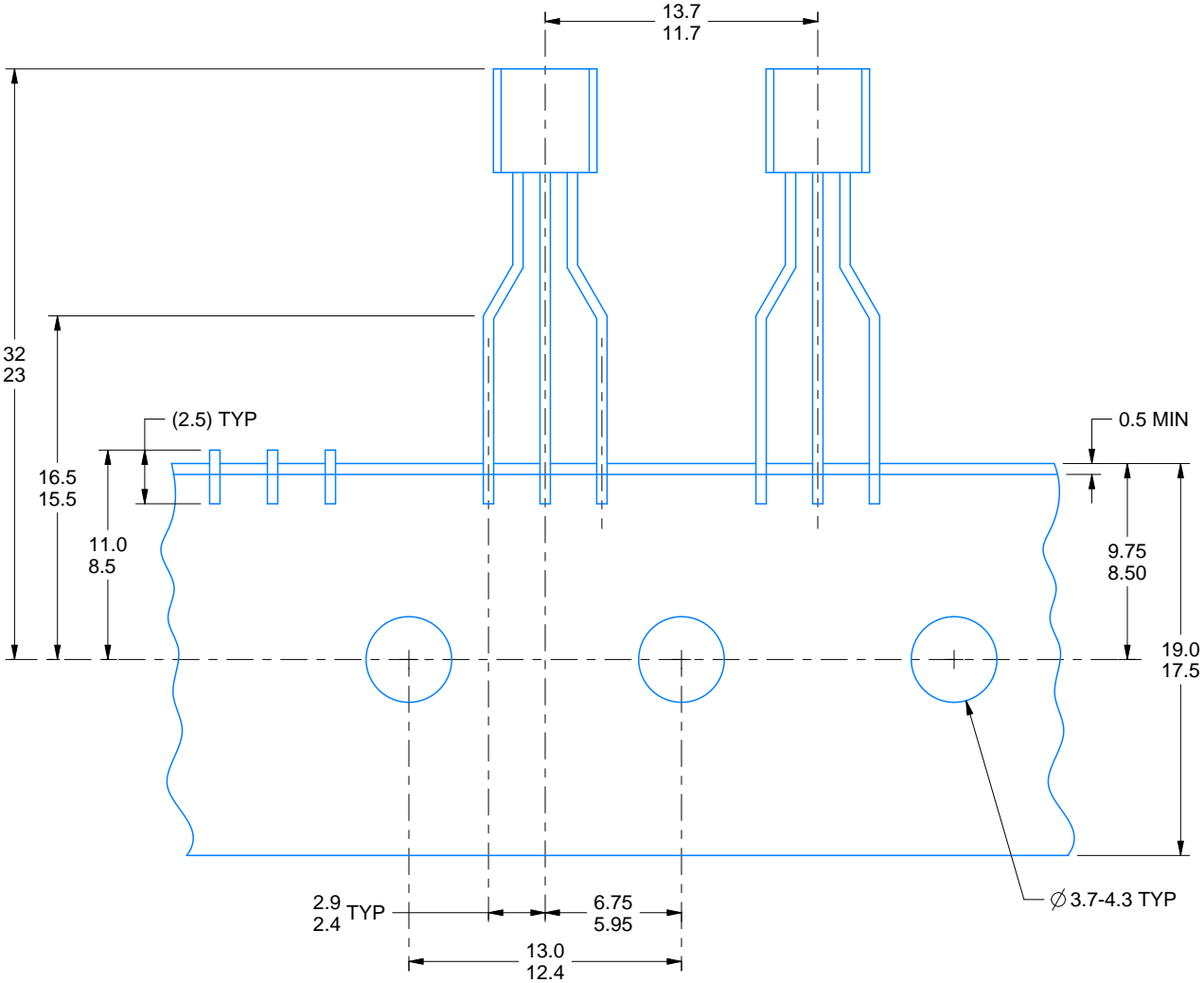
4215214/B 04/2017

TAPE SPECIFICATIONS

LP0003A

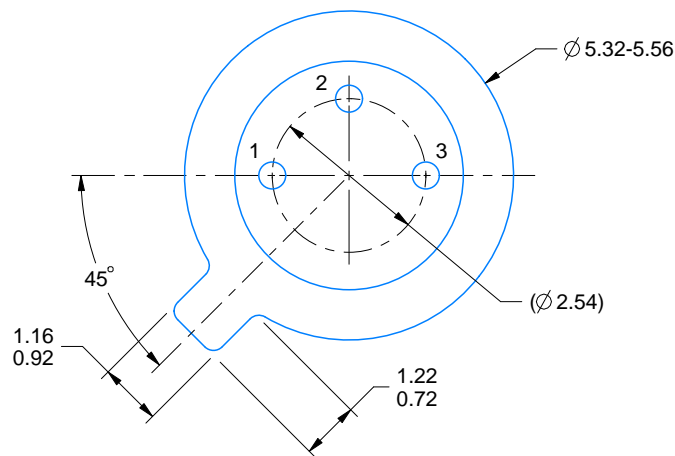
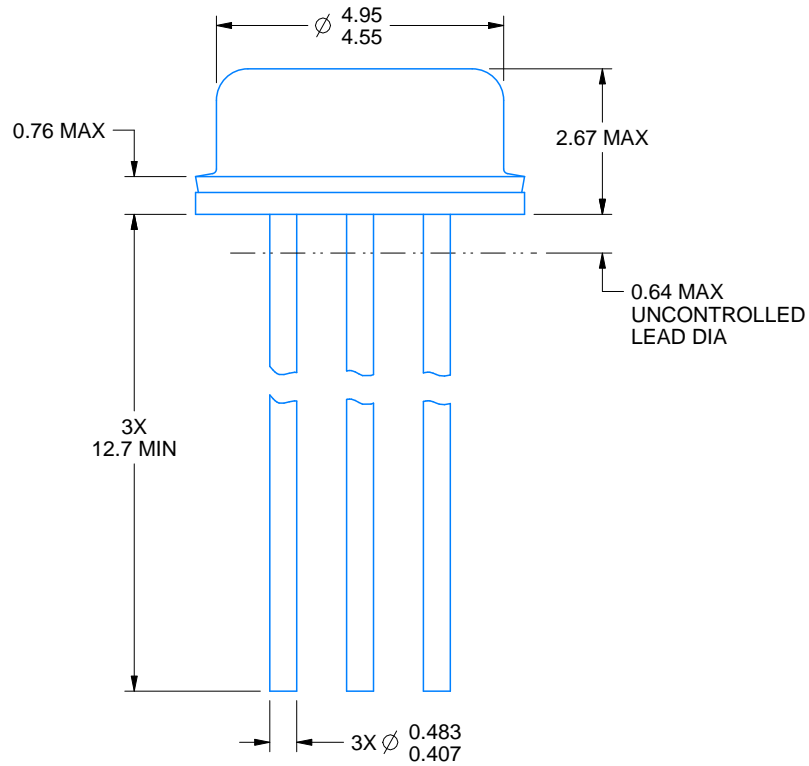
TO-92 - 5.34 mm max height

TO-92



FOR FORMED LEAD OPTION PACKAGE

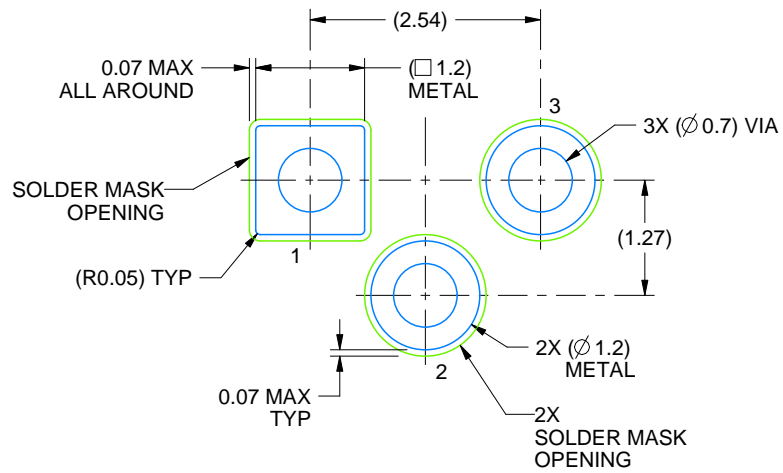
4215214/B 04/2017



4219876/A 01/2017

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.



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

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