LM35

LM35 Precision Centigrade Temperature Sensors

Literature Number: SNIS159B
LM35
Precision Centigrade Temperature Sensors

General Description
The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35’s low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55°C to +150°C temperature range, while the LM35C is rated for a −40°C to +110°C range (−10°C with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

Features
- Calibrated directly in °Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guaranteed (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±1/4°C typical
- Low impedance output, 0.1 Ω for 1 mA load

Typical Applications

Choose \( R_1 = -V_S/50 \) µA
\[
V_{OUT} = \begin{cases} 
1,500 \text{ mV at } +150°C \\
+250 \text{ mV at } +25°C \\
-550 \text{ mV at } -55°C 
\end{cases}
\]

Figure 1. Basic Centigrade Temperature Sensor (+2°C to +150°C)
Figure 2. Full-Range Centigrade Temperature Sensor
Connection Diagrams

TO-46  
Metal Can Package*

*Case is connected to negative pin (GND)

Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH  
See NS Package Number H03H

TO-92  
Plastic Package

Order Number LM35CZ, LM35CAZ or LM35DZ  
See NS Package Number Z03A

SO-8  
Small Outline Molded Package

N.C. = No Connection

Top View  
Order Number LM35DM  
See NS Package Number M08A

TO-220  
Plastic Package*

*Tab is connected to the negative pin (GND).

Note: The LM35DT pinout is different than the discontinued LM35DP.

Order Number LM35DT  
See NS Package Number TA03F

Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH  
See NS Package Number H03H

Order Number LM35CZ, LM35CAZ or LM35DZ  
See NS Package Number Z03A

*Case is connected to negative pin (GND)
### Absolute Maximum Ratings (Note 10)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

- **Supply Voltage**: +35V to −0.2V
- **Output Voltage**: +6V to −1.0V
- **Output Current**: 10 mA
- **Storage Temp.**:
  - TO-46 Package, −60°C to +180°C
  - TO-92 Package, −60°C to +150°C
  - SO-8 Package, −65°C to +150°C
  - TO-220 Package, −65°C to +150°C
- **Lead Temp.**:
  - TO-46 Package, (Soldering, 10 seconds) 300°C
  - TO-92 and TO-220 Package, (Soldering, 10 seconds) 260°C
  - Vapor Phase (60 seconds) 215°C
  - Infrared (15 seconds) 220°C
- **ESD Susceptibility (Note 11)**: 2500V

### Specified Operating Temperature Range: $T_{\text{MIN}}$ to $T_{\text{MAX}}$ (Note 2)

- LM35, LM35A: −55°C to +150°C
- LM35C, LM35CA: −40°C to +110°C
- LM35D: 0°C to +100°C

### Electrical Characteristics (Notes 1, 6)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM35A Tested Limit</th>
<th>LM35A Design Limit</th>
<th>LM35CA Tested Limit</th>
<th>LM35CA Design Limit</th>
<th>Units (Max.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy</strong></td>
<td>$T_A=+25°C$</td>
<td>±0.2</td>
<td>±0.5</td>
<td>±0.2</td>
<td>±0.5</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td>$T_A=−10°C$</td>
<td>±0.3</td>
<td>±1.0</td>
<td>±0.3</td>
<td>±1.0</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td>$T_A=T_{\text{MAX}}$</td>
<td>±0.4</td>
<td>±1.0</td>
<td>±0.4</td>
<td>±1.0</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td>$T_A=T_{\text{MIN}}$</td>
<td>±0.4</td>
<td>±1.0</td>
<td>±0.4</td>
<td>±1.5</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Nonlinearity</strong></td>
<td>$T_{\text{MIN}}\leq T_A\leq T_{\text{MAX}}$</td>
<td>±0.18</td>
<td>±0.35</td>
<td>±0.15</td>
<td>±0.3</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Sensor Gain</strong></td>
<td>$T_{\text{MIN}}\leq T_A\leq T_{\text{MAX}}$</td>
<td>+10.0, +9.9, +10.1</td>
<td>+10.0</td>
<td>+9.9, +10.1</td>
<td>mV/°C</td>
<td></td>
</tr>
<tr>
<td><strong>Load Regulation</strong></td>
<td>$T_A=+25°C$</td>
<td>±0.4</td>
<td>±1.0</td>
<td>±0.4</td>
<td>±1.0</td>
<td>mV/mA</td>
</tr>
<tr>
<td>(Note 3) 0≤I_L≤1 mA</td>
<td>$T_{\text{MIN}}\leq T_A\leq T_{\text{MAX}}$</td>
<td>±0.5</td>
<td>±3.0</td>
<td>±0.5</td>
<td>±3.0</td>
<td>mV/mA</td>
</tr>
<tr>
<td><strong>Line Regulation</strong></td>
<td>$T_A=+25°C$</td>
<td>±0.01</td>
<td>±0.05</td>
<td>±0.01</td>
<td>±0.05</td>
<td>mV/V</td>
</tr>
<tr>
<td>(Note 3) 4≤V_S≤30V</td>
<td>$T_{\text{MIN}}\leq T_A\leq T_{\text{MAX}}$</td>
<td>±0.02</td>
<td>±0.1</td>
<td>±0.02</td>
<td>±0.1</td>
<td>mV/V</td>
</tr>
<tr>
<td><strong>Quiescent Current</strong></td>
<td>$V_S=+5V$</td>
<td>56</td>
<td>67</td>
<td>56</td>
<td>67</td>
<td>µA</td>
</tr>
<tr>
<td>(Note 9)</td>
<td>$+25°C$</td>
<td>105</td>
<td>131</td>
<td>91</td>
<td>114</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td>$V_S=+5V$</td>
<td>56.2</td>
<td>68</td>
<td>56.2</td>
<td>68</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td>$+30V$</td>
<td>105.5</td>
<td>133</td>
<td>91.5</td>
<td>116</td>
<td>µA</td>
</tr>
<tr>
<td><strong>Temperature Coefficient of</strong></td>
<td>$V_S=+30V$, +25°C</td>
<td>0.2</td>
<td>1.0</td>
<td>0.2</td>
<td>1.0</td>
<td>µA/°C</td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>(Note 3)</td>
<td>0.5</td>
<td>2.0</td>
<td>0.5</td>
<td>2.0</td>
<td>µA/°C</td>
</tr>
<tr>
<td><strong>Minimum Temperature for</strong></td>
<td>$T_J=T_{\text{MAX}}$,</td>
<td>±0.08</td>
<td>±0.08</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>Rated Accuracy</td>
<td>for 1000 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

(Note 10) Absolute Maximum Ratings

(Note 1) If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

(Note 2) Specified Operating Temperature Range: $T_{\text{MIN}}$ to $T_{\text{MAX}}$

(Note 3) Unless otherwise specified, all limits are $T_{\text{MIN}}$ to $T_{\text{MAX}}$

(Note 4) $T_{\text{MIN}}$ to $T_{\text{MAX}}$

(Note 5) $T_{\text{MIN}}$ to $T_{\text{MAX}}$

(Note 6) Electrical Characteristics

(Note 7) Accuracy

(Note 8) Nonlinearity

(Note 9) Quiescent Current

(Note 11) ESD Susceptibility

(Note 12) SO Package

www.national.com
### Electrical Characteristics

(Notes 1, 6)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>LM35</th>
<th>LM35C, LM35D</th>
<th>Units (Max.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Typical</td>
<td>Tested Limit (Note 4)</td>
<td>Design Limit (Note 5)</td>
</tr>
<tr>
<td>Accuracy, LM35, LM35C (Note 7)</td>
<td>$T_A=+25^\circ$ C</td>
<td>±0.4 ±1.0</td>
<td>±0.4 ±1.0</td>
<td>±0.4 ±1.0 °C</td>
</tr>
<tr>
<td></td>
<td>$T_A=−10^\circ$ C</td>
<td>±0.5 ±1.5</td>
<td>±0.5 ±1.5</td>
<td>±0.5 ±1.5 °C</td>
</tr>
<tr>
<td></td>
<td>$T_A=T_{\text{MAX}}$</td>
<td>±0.8 ±1.5</td>
<td>±0.8 ±1.5</td>
<td>±0.8 ±1.5 °C</td>
</tr>
<tr>
<td></td>
<td>$T_A=T_{\text{MIN}}$</td>
<td>±0.8 ±1.5</td>
<td>±0.8 ±1.5</td>
<td>±0.8 ±1.5 °C</td>
</tr>
<tr>
<td>Accuracy, LM35D (Note 7)</td>
<td>$T_A=+25^\circ$ C</td>
<td>±0.6 ±1.5</td>
<td>±0.9 ±2.0</td>
<td>±0.9 ±2.0 °C</td>
</tr>
<tr>
<td></td>
<td>$T_A=T_{\text{MAX}}$</td>
<td>±0.9 ±2.0</td>
<td>±0.9 ±2.0</td>
<td>±0.9 ±2.0 °C</td>
</tr>
<tr>
<td></td>
<td>$T_A=T_{\text{MIN}}$</td>
<td>±0.9 ±2.0</td>
<td>±0.9 ±2.0</td>
<td>±0.9 ±2.0 °C</td>
</tr>
<tr>
<td>Nonlinearity (Note 8)</td>
<td>$T_{\text{MIN}}\leq T_A \leq T_{\text{MAX}}$</td>
<td>±0.3 ±0.5</td>
<td>±0.2 ±0.5</td>
<td>±0.5 ±0.5 °C</td>
</tr>
<tr>
<td>Sensor Gain (Average Slope)</td>
<td>$T_{\text{MIN}}\leq T_A \leq T_{\text{MAX}}$</td>
<td>±10.0 ±9.8, ±10.2</td>
<td>±10.0 ±9.8, ±10.2</td>
<td>mV/°C</td>
</tr>
<tr>
<td>Load Regulation (Note 3)</td>
<td>$0 \leq I_L \leq 1\text{ mA}$</td>
<td>±0.4 ±2.0</td>
<td>±0.4 ±2.0</td>
<td>±0.4 ±2.0 mV/mA</td>
</tr>
<tr>
<td>Line Regulation (Note 3)</td>
<td>$V_S=+5V, +25^\circ$ C</td>
<td>±0.01 ±0.1</td>
<td>±0.01 ±0.1</td>
<td>±0.1 ±0.1 mV/V</td>
</tr>
<tr>
<td></td>
<td>$4V \leq V_S \leq 30V$</td>
<td>±0.02 ±0.2</td>
<td>±0.02 ±0.2</td>
<td>±0.2 ±0.2 mV/V</td>
</tr>
<tr>
<td>Quiescent Current (Note 9)</td>
<td>$V_S=+5V, +25^\circ$ C</td>
<td>56 80</td>
<td>56 80</td>
<td>138 µA</td>
</tr>
<tr>
<td></td>
<td>$V_S=+5V$</td>
<td>105 158</td>
<td>91 138</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td>$V_S=+30V, +25^\circ$ C</td>
<td>56.2 82</td>
<td>56.2 82</td>
<td>141 µA</td>
</tr>
<tr>
<td></td>
<td>$V_S=+30V$</td>
<td>105.5 161</td>
<td>91.5 141</td>
<td>µA</td>
</tr>
<tr>
<td>Change of Quiescent Current (Note 3)</td>
<td>$4V \leq V_S \leq 30V, +25^\circ$ C</td>
<td>0.2 2.0</td>
<td>0.2 2.0</td>
<td>3.0 µA</td>
</tr>
<tr>
<td></td>
<td>$4V \leq V_S \leq 30V$</td>
<td>0.5 3.0</td>
<td>0.5 3.0</td>
<td>µA</td>
</tr>
<tr>
<td>Temperature Coefficient of Quiescent Current</td>
<td>$T_J=T_{\text{MAX}}$, for 1000 hours</td>
<td>+0.39 0.7</td>
<td>+0.39 0.7</td>
<td>+0.7 µA/°C</td>
</tr>
<tr>
<td>Minimum Temperature for Rated Accuracy</td>
<td>In circuit of $T_{\text{MIN}}$, $I_L=0$</td>
<td>+1.5 +2.0</td>
<td>+1.5 +2.0</td>
<td>+2.0 °C</td>
</tr>
<tr>
<td>Long Term Stability</td>
<td>$T_J=T_{\text{MAX}}$, for 1000 hours</td>
<td>±0.08 ±0.08</td>
<td>±0.08 ±0.08</td>
<td>°C</td>
</tr>
</tbody>
</table>

#### Notes:
- **Note 1:** Unless otherwise noted, these specifications apply: $−55^\circ$C $\leq T_J \leq +150^\circ$C for the LM35 and LM35A; $−40^\circ$C $\leq T_J \leq +110^\circ$C for the LM35C and LM35CA; and $0^\circ$C $\leq T_J \leq +100^\circ$C for the LM35D. $V_S=+5V_{dc}$ and $I_{\text{LOAD}}=50$ µA, in the circuit of Figure 2. These specifications also apply from $+2^\circ$C to $T_{\text{MAX}}$ in the circuit of Figure 1. Specifications in **boldface** apply over the full rated temperature range.
- **Note 2:** Specifications in **boldface** apply over the full rated temperature range.
- **Note 3:** Design limits are guaranteed (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.
- **Note 4:** Tested Limits are guaranteed and 100% tested in production.
- **Note 5:** 4V $\leq V_S \leq 30V$, +25°C.
- **Note 6:** Specifications in **boldface** apply over the full rated temperature range.
- **Note 7:** Accuracy is defined as the error between the output voltage and 10mV/°C times the device’s case temperature, at specified conditions of voltage, current, and temperature (expressed in °C).
- **Note 8:** Nonlinearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the device’s rated temperature range.
- **Note 9:** Quiescent current is defined in the circuit of Figure 1.
- **Note 10:** 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. See Note 1.
- **Note 11:** Human body model, 100 pF discharged through a 1.5 kΩ resistor.
- **Note 12:** See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” or the section titled “Surface Mount” found in a current National Semiconductor Linear Data Book for other methods of soldering surface mount devices.
Typical Performance Characteristics

Thermal Resistance
Junction to Air

Thermal Time Constant

Thermal Response
in Still Air

Thermal Response in
Stirred Oil Bath

Minimum Supply
Voltage vs. Temperature

Quiescent Current
vs. Temperature
(In Circuit of Figure 1.)

Accuracy vs. Temperature
(Guaranteed)

Quiescent Current
vs. Temperature
(In Circuit of Figure 2.)

Accuracy vs. Temperature
(Guaranteed)
Applications

The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01˚C of the surface temperature.

This 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, where the copper leads 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.

To minimize this problem, be sure that the wiring to the LM35, as it leaves the device, is held at the same temperature as the surface of interest. The easiest way to do this is to cover up these wires with a bead of epoxy which will insure that the leads and wires are all at the same temperature as the surface, and that the LM35 die’s temperature will not be affected by the air temperature.

Temperature Rise of LM35 Due To Self-heating (Thermal Resistance, $\theta_{JA}$)

<table>
<thead>
<tr>
<th></th>
<th>TO-46, no heat sink</th>
<th>TO-46*, small heat fin</th>
<th>TO-92, no heat sink</th>
<th>TO-92**, small heat fin</th>
<th>SO-8, no heat sink</th>
<th>SO-8**, small heat fin</th>
<th>TO-220, no heat sink</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still air</td>
<td>400˚C/W</td>
<td>100˚C/W</td>
<td>180˚C/W</td>
<td>140˚C/W</td>
<td>220˚C/W</td>
<td>110˚C/W</td>
<td>90˚C/W</td>
</tr>
<tr>
<td>Moving air</td>
<td>100˚C/W</td>
<td>40˚C/W</td>
<td>90˚C/W</td>
<td>70˚C/W</td>
<td>105˚C/W</td>
<td>90˚C/W</td>
<td>26˚C/W</td>
</tr>
<tr>
<td>Still oil</td>
<td>100˚C/W</td>
<td>40˚C/W</td>
<td>90˚C/W</td>
<td>70˚C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stirred oil</td>
<td>50˚C/W</td>
<td>30˚C/W</td>
<td>45˚C/W</td>
<td>40˚C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Clamped to metal, Infinite heat sink)</td>
<td>(24˚C/W)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(55˚C/W)</td>
</tr>
</tbody>
</table>

*Wakefield type 201, or 1” disc of 0.020” sheet brass, soldered to case, or similar.

**TO-92 and SO-8 packages glued and leads soldered to 1” square of 1/16” printed circuit board with 2 oz. foil or similar.
Typical Applications

CAPACITIVE LOADS
Like most micropower circuits, the LM35 has a limited ability to drive heavy capacitive loads. The LM35 by itself is able to drive 50 pf without special precautions. If heavier loads are anticipated, it is easy to isolate or decouple the load with a resistor; see Figure 3. Or you can improve the tolerance of capacitance with a series R-C damper from output to ground; see Figure 4.

When the LM35 is applied with a 200Ω load resistor as shown in Figure 5, Figure 6 or Figure 8 it is relatively immune to wiring capacitance because the capacitance forms a bypass from ground to input, not on the output. However, as with any linear circuit connected to wires in a hostile environment, its performance can be affected adversely by intense electromagnetic sources such as relays, radio transmitters, motors with arcing brushes, SCR transients, etc, as its wiring can act as a receiving antenna and its internal junctions can act as rectifiers. For best results in such cases, a bypass capacitor from VIN to ground and a series R-C damper such as 75Ω in series with 0.2 or 1 µF from output to ground are often useful. These are shown in Figure 13, Figure 14, and Figure 16.

FIGURE 3. LM35 with Decoupling from Capacitive Load

FIGURE 4. LM35 with R-C Damper

FIGURE 5. Two-Wire Remote Temperature Sensor (Grounded Sensor)

FIGURE 6. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

FIGURE 7. Temperature Sensor, Single Supply, −55˚ to +150˚C

FIGURE 8. Two-Wire Remote Temperature Sensor (Output Referred to Ground)

FIGURE 9. 4-To-20 mA Current Source (0˚C to +100˚C)
Typical Applications (Continued)

FIGURE 10. Fahrenheit Thermometer

FIGURE 11. Centigrade Thermometer (Analog Meter)

FIGURE 12. Fahrenheit Thermometer Expanded Scale Thermometer (50° to 80° Fahrenheit, for Example Shown)

FIGURE 13. Temperature To Digital Converter (Serial Output) (+128°C Full Scale)

FIGURE 14. Temperature To Digital Converter (Parallel TRI-STATE™ Outputs for Standard Data Bus to µP Interface) (128°C Full Scale)
Typical Applications (Continued)

- Trim R_b for V_b = 3.075V
- Trim R_c for V_c = 1.955V
- Trim R_a for V_a = 0.075V + 100mV/°C x T_ambient
  Example, V_a = 2.275V at 22°C

FIGURE 15. Bar-Graph Temperature Display (Dot Mode)

FIGURE 16. LM35 With Voltage-To-Frequency Converter And Isolated Output
(2°C to +150°C; 20 Hz to 1500 Hz)
Physical Dimensions  inches (millimeters) unless otherwise noted

TO-46 Metal Can Package (H)
Order Number LM35H, LM35AH, LM35CH, LM35CAH, or LM35DH
NS Package Number H03H

SO-8 Molded Small Outline Package (M)
Order Number LM35DM
NS Package Number M08A
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

Power Package TO-220 (T)
Order Number LM35DT
NS Package Number TA03F
LIFE SUPPORT POLICY

NATIONAL’S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.
# IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for such any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use. TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any damages arising out of the use of TI products in such safety-critical applications.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

<table>
<thead>
<tr>
<th>Products</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio</td>
<td>Communications and Telecom</td>
</tr>
<tr>
<td>Amplifiers</td>
<td>Computers and Peripherals</td>
</tr>
<tr>
<td>Data Converters</td>
<td>Consumer Electronics</td>
</tr>
<tr>
<td>DLP® Products</td>
<td>Energy and Lighting</td>
</tr>
<tr>
<td>DSP</td>
<td>Industrial</td>
</tr>
<tr>
<td>Clocks and Timers</td>
<td>Medical</td>
</tr>
<tr>
<td>Interface</td>
<td>Security</td>
</tr>
<tr>
<td>Logic</td>
<td>Space, Avionics and Defense</td>
</tr>
<tr>
<td>Power Mgmt</td>
<td>Transportation and Automotive</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Video and Imaging</td>
</tr>
<tr>
<td>RFID</td>
<td></td>
</tr>
<tr>
<td>OMAP Mobile Processors</td>
<td></td>
</tr>
<tr>
<td>Wireless Connectivity</td>
<td></td>
</tr>
</tbody>
</table>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated