National Semiconductor

LM34 Precision Fahrenheit Temperature Sensors

General Description

Connection Diagrams TO-46 Metal Can Package

(Note 1)

Vour

GNDC

Order Numbers LM34H,

LM34AH, LM34CH,

LM34CAH or LM34DH

See NS Package

Number H03H

Note 1: Case is connected to negative pin (GND).

The LM34 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Fahrenheit temperature. The LM34 thus has an advantage over linear temperature sensors calibrated in degrees Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Fahrenheit scaling. The LM34 does not require any external calibration or trimming to provide typical accuracies of ±1/2°F at room temperature and ±11/2°F over a full -50 to +300°F temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM34'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 75 µA from its supply, it has very low self-heating, less than 0.2°F in still air. The LM34 is rated to operate over a -50° to +300°F temperature range, while the LM34C is rated for a -40° to +230°F range (0°F with improved accuracy). The LM34 series is available packaged in

hermetic TO-46 transistor packages, while the LM34C, LM34CA and LM34D are also available in the plastic TO-92 transistor package. The LM34D is also available in an 8-lead surface mount small outline package. The LM34 is a complement to the LM35 (Centigrade) temperature sensor. LM34 Precision Fahrenheit Temperature Sensors

July 1999

Features

- Calibrated directly in degrees Fahrenheit
- Linear +10.0 mV/°F scale factor
- 1.0°F accuracy guaranteed (at +77°F)
- Rated for full –50° to +300°F range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Deperates from 5 to 30 volts
- Less than 90 µA current drain
- Low self-heating, 0.18°F in still air



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Absolute Maximum Ratings (Note 11)

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

Distributors for availability and specifications.		(Soldering, 10 seconds)	+260°C
Supply Voltage	+35V to -0.2V	SO Package (Note 13)	
Output Voltage	+6V to -1.0V	Vapor Phase (60 seconds)	215°C
Output Current	10 mA	Infrared (15 seconds)	220°C
Storage Temperature,		Specified Operating Temp. Range (No	ote 3)
TO-46 Package	–76°F to +356°F		T _{MIN} to T _{MAX}
TO-92 Package	–76°F to +300°F	LM34, LM34A	–50°F to +300°F
SO-8 Package	–65°C to +150°C	LM34C, LM34CA	-40°F to +230°F
ESD Susceptibility (Note 12)	800V	LM34D	+32°F to +212°F

TO-46 Package

TO-92 Package

(Soldering, 10 seconds)

Lead Temp.

DC Electrical Characteristics (Notes 2, 7)

		LM34A		LM34CA				
Parameter	Conditions		Tested	Design		Tested	Design	Units
		Typical	Limit	Limit	Typical	Limit	Limit	(Max)
			(Note 5)	(Note 6)		(Note 5)	(Note 6)	
Accuracy (Note 8)	T _A = +77°F	±0.4	±1.0		±0.4	±1.0		°F
	$T_A = 0^{\circ}F$	±0.6			±0.6		±2.0	°F
	$T_A = T_{MAX}$	±0.8	±2.0		±0.8	±2.0		°F
	$T_A = T_{MIN}$	±0.8	±2.0		±0.8		±3.0	°F
Nonlinearity (Note 9)	$T_{MIN} \le T_A \le T_{MAX}$	±0.35		±0.7	±0.30		±0.6	°F
Sensor Gain	$T_{MIN} \le T_A \le T_{MAX}$	+10.0	+9.9,		+10.0		+9.9,	mV/°F, min
(Average Slope)			+10.1				+10.1	mV/°F, max
Load Regulation	T _A = +77°F	±0.4	±1.0		±0.4	±1.0		mV/mA
(Note 4)	$T_{MIN} \leq T_{A} \leq T_{MAX}$	±0.5		±3.0	±0.5		±3.0	mV/mA
	$0 \le I_L \le 1 \text{ mA}$							
Line Regulation	$T_A = +77^{\circ}F$	±0.01	±0.05		±0.01	±0.05		mV/V
(Note 4)	$5V \le V_S \le 30V$	±0.02		±0.1	±0.02		±0.1	mV/V
Quiescent Current	V _S = +5V, +77°F	75	90		75	90		μA
(Note 10)	$V_{S} = +5V$	131		160	116		139	μΑ
	V _S = +30V, +77°F	76	92		76	92		μΑ
	$V_{s} = +30V$	132		163	117		142	μΑ
Change of Quiescent	$4V \le V_S \le 30V, +77^{\circ}F$	+0.5	2.0		0.5	2.0		μΑ
Current (Note 4)	$5V \le V_S \le 30V$	+1.0		3.0	1.0		3.0	μΑ
Temperature Coefficient		+0.30		+0.5	+0.30		+0.5	µA/°F
of Quiescent Current								
Minimum Temperature	In circuit of Figure 1,	+3.0		+5.0	+3.0		+5.0	°F
for Rated Accuracy	$I_{L} = 0$							
Long-Term Stability	$T_j = T_{MAX}$ for 1000 hours	±0.16			±0.16			°F

Note 2: Unless otherwise noted, these specifications apply: $-50^{\circ}F \le T_j \le +300^{\circ}F$ for the LM34 and LM34A; $-40^{\circ}F \le T_j \le +230^{\circ}F$ for the LM34C and LM34CA; and $+32^{\circ}F \le T_j \le +212^{\circ}F$ for the LM34D. V_S = +5 Vdc and I_{LOAD} = 50 µA in the circuit of *Figure 2*; +6 Vdc for LM34 and LM34A for 230^{\circ}F \le T_j \le 300^{\circ}F. These specifications also apply from +5'F to T_{MAX} in the circuit of *Figure 1*.

Note 3: Thermal resistance of the TO-46 package is 720°F/W junction to ambient and 43°F/W junction to case. Thermal resistance of the TO-92 package is 324°F/W junction to ambient. Thermal resistance of the small outline molded package is 400°F/W junction to ambient. For additional thermal resistance information see table in the Typical Applications section.

Note 4: 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.

Note 5: Tested limits are guaranteed and 100% tested in production.

Note 6: 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 7: Specification in BOLDFACE TYPE apply over the full rated temperature range.

+300°C

DC Electrical Characteristics (Notes 2, 7) (Continued)

Note 8: Accuracy is defined as the error between the output voltage and 10 mV/°F times the device's case temperature at specified conditions of voltage, current, and temperature (expressed in °F).

Note 9: 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 10: Quiescent current is defined in the circuit of Figure 1.

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Note 11: 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 (Note 2).

Note 12: Human body model, 100 pF discharged through a 1.5 k Ω resistor.

Note 13: 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.

DC Electrical Characteristics (Notes 2, 7)

		LM34		LM34C, LM34D				
Parameter	Conditions		Tested	Design		Tested	Design	Units
		Typical	Limit	Limit	Typical	Limit	Limit	(Max)
			(Note 5)	(Note 6)		(Note 5)	(Note 6)	
Accuracy, LM34, LM34C	$T_A = +77^{\circ}F$	±0.8	±2.0		±0.8	±2.0		°F
(Note 8)	$T_A = 0^{\circ}F$	±1.0			±1.0		±3.0	°F
	$T_A = T_{MAX}$	±1.6	±3.0		±1.6		±3.0	°F
	$T_A = T_{MIN}$	±1.6		±3.0	±1.6		±4.0	°F
Accuracy, LM34D	T _A = +77°F				±1.2	±3.0		°F
(Note 8)	$T_A = T_{MAX}$				±1.8		±4.0	°F
	$T_A = T_{MIN}$				±1.8		±4.0	°F
Nonlinearity (Note 9)	$T_{MIN} \le T_A \le T_{MAX}$	±0.6		±1.0	±0.4		±1.0	°F
Sensor Gain	$T_{MIN} \le T_A \le T_{MAX}$	+10.0	+9.8,		+10.0		+9.8,	mV/°F, min
(Average Slope)			+10.2				+10.2	mV/°F, max
Load Regulation	$T_A = +77^{\circ}F$	±0.4	±2.5		±0.4	±2.5		mV/mA
(Note 4)	$T_{MIN} \le T_A \le +150^{\circ}F$	±0.5		±6.0	±0.5		±6.0	mV/mA
	$0 \le I_L \le 1 \text{ mA}$							
Line Regulation	$T_A = +77^{\circ}F$	±0.01	±0.1		±0.01	±0.1		mV/V
(Note 4)	$5V \le V_S \le 30V$	±0.02		±0.2	±0.02		±0.2	mV/V
Quiescent Current	V _S = +5V, +77°F	75	100		75	100		μA
(Note 10)	$V_{S} = +5V$	131		176	116		154	μA
	V _S = +30V, +77°F	76	103		76	103		μA
	V _S = +30V	132		181	117		159	μA
Change of Quiescent	$4V \le V_S \le 30V, +77^{\circ}F$	+0.5	3.0		0.5	3.0		μA
Current (Note 4)	$5V \le V_S \le 30V$	+1.0		5.0	1.0		5.0	μA
Temperature Coefficient		+0.30		+0.7	+0.30		+0.7	µA/°F
of Quiescent Current								
Minimum Temperature	In circuit of Figure 1,	+3.0		+5.0	+3.0		+5.0	°F
for Rated Accuracy	$I_{L} = 0$							
Long-Term Stability	$T_j = T_{MAX}$ for 1000 hours	±0.16			±0.16			°F



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Noise Voltage



Typical Applications

The LM34 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 0.02°F 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 LM34 die would be at an intermediate temperature. This is expecially 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.

To minimize this problem, be sure that the wiring to the LM34, 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 LM34 die's temperature will not be 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, the LM34 can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the LM34 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 Humiseal and epoxy paints or dips are often used to insure that moisture cannot corrode the LM34 or its connections.



These devices are sometimes soldered to a small, light-weight heat fin to decrease the thermal time constant

Start-Up Response

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.

Capacitive Loads

Like most micropower circuits, the LM34 has a limited ability to drive heavy capacitive loads. The LM34 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 LM34 is applied with a 499Ω load resistor (as shown), 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's 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 V_{IN} 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 the following circuits.





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