

LM135-LM235-LM335

Precision temperature sensors

Features

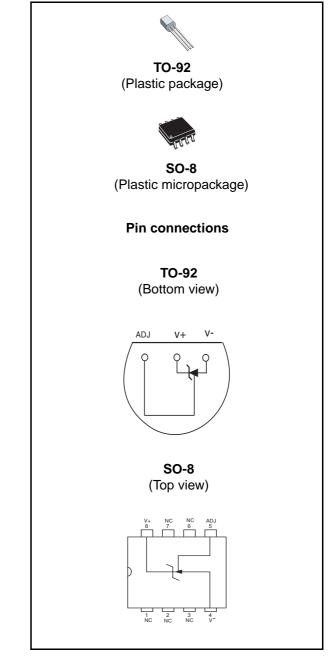
- Directly calibrated in °K
- 1°C initial accuracy
- Operates from 450µA to 5mA
- Less than 1Ω dynamic impedance

Description

The LM135, LM235, LM335 are precision temperature sensors which can be easily calibrated. They operate as a 2-terminal Zener and the breakdown voltage is directly proportional to the absolute temperature at 10mV/°K.

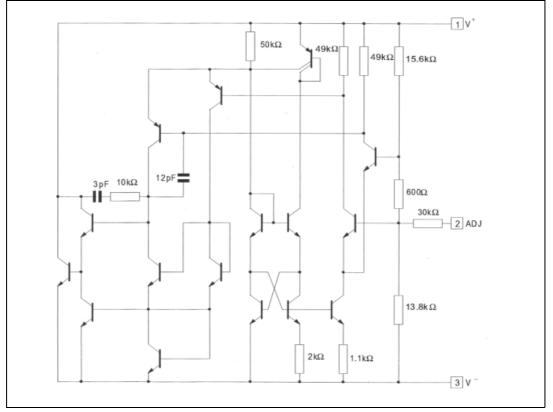
The circuit has a dynamic impedance of less than 1Ω and operates within a range of current from 450μ A to 5mA without alteration of its characteristics.

Calibrated at +25°C, the LM135, LM235, and LM335 have a typical error of less than 1°C over a 100°C temperature range. Unlike other sensors, the LM135, LM235, LM335 have a linear output.



1 Schematic diagram





2 Absolute maximum ratings

 Table 1.
 Absolute maximum ratings (AMR)

Symbol	Parameter	LM135	LM235	LM335- LM335A	Unit
I _R I _F	Current Reverse Forward		15 10		mA
T _{oper}	Operating free-air temperature range ⁽¹⁾ Continuous Intermittent	-55 to +150 +150 to +200	-40 to +125 +125 to +150	-40 to +100 +100 to +125	°C
T _{stg}	Storage temperature range	-65 to +150			°C

1. $T_j \le 150^{\circ}C$

3 Temperature accuracy

Table 2. Temperature accuracy

Parameter		LM135 - LM235 - LM335A			LM335		
	Min.	Тур.	Max.	Min.	Тур.	Max.	
Operating output voltage T _{case} = +25°C, I _R = 1mA	2.95	2.98	3.01	2.92	2.98	3.04	V
$ \begin{array}{l} \mbox{Uncalibrated temperature error (I_R = 1mA)} \\ T_{case} = +25^{\circ}C \\ T_{min} \leq T_{case} \leq T_{max} \end{array} $		1 2	3 5		4 5	6 9	°C
Temperature error with 25°C calibration $T_{min} \leq T_{case} \leq T_{max}$, $I_R = 1mA$ LM135 - LM235 LM335 LM335A		0.5 0.5	1.5 1		1	2	°C
Calibrated error at extended temperature T _{case} = T _{max} (intermittent)		2			2		°C
Non-linearity (I _R = 1mA) LM135 - LM235 LM335 LM335A		0.3 0.3	1 1.5		0.3	1.5	°C

4 Electrical characteristics

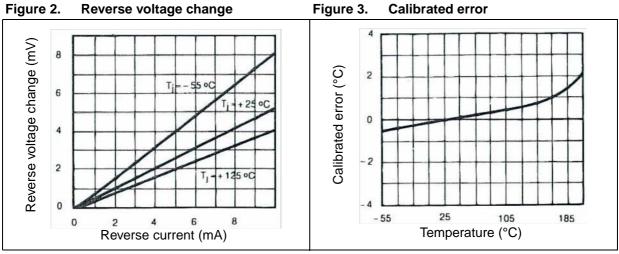
Table 3. Electrical characteristics

Parameter		LM135 - LM235			LM335-LM335A		
Farameter	Min.	Тур.	Max.	Min.	Тур.	Max.	Unit
Operating output voltage change with current $450\mu A \le I_R \le 5mA$ at constant temperature		2.5	10		3	14	mV
Dynamic impedance (I _R = 1mA)		0.5			0.6		Ω
Output voltage temperature drift		+10			+10		mV/°C
Time constant Still air Air 0.5m/s Stirred oil		80 10 1			80 10 1		S
Time stability (T _{case} = +125°C)		0.2			0.2		°C/kh

Note: Accuracy measurements are made in a well-stirred oil bath. For other conditions, selfheating must be considered

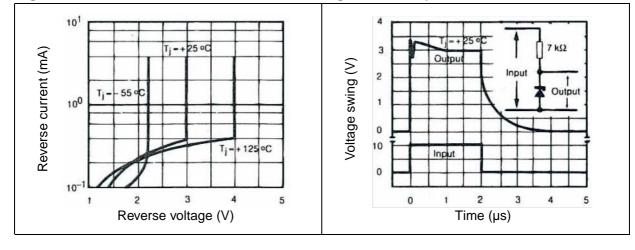


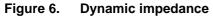
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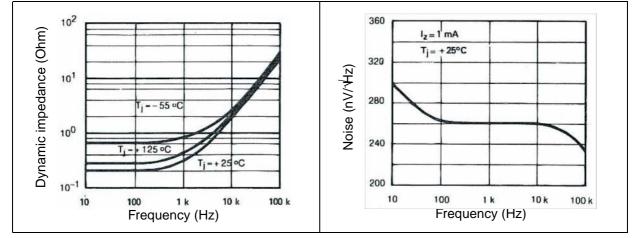


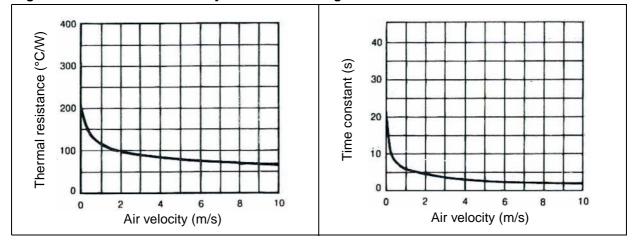


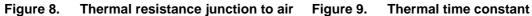


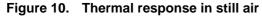














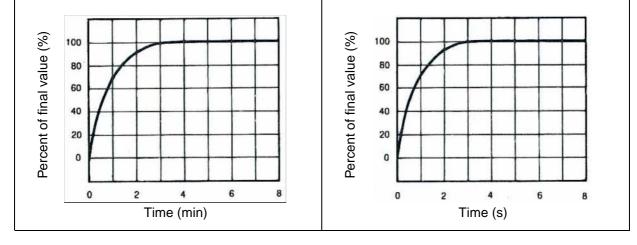
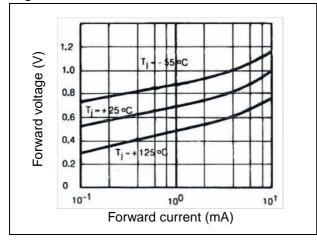


Figure 12. Forward characteristics



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5 Application information

There is an easy method of calibrating the device for higher accuracies (see *Typical applications*).

The single point calibration works because the output of the LM135, LM235, LM335 is proportional to the absolute temperature with the extrapolated output of sensor going to 0V at 0°K (-273.15°C). Errors in output voltage versus temperature are only slope. Thus a calibration of the slope at one temperature corrects errors at all temperatures.

The circuit output (calibrated or not) is given by the equation:

$$V_{OT} + VO_{TO} \times \frac{T}{T_0}$$

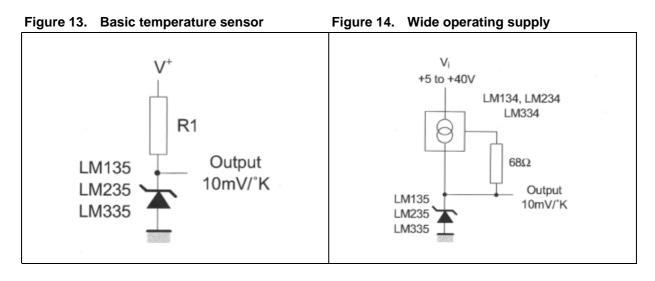
where T is the unknown temperature and To is the reference temperature (in °K).

Nominally, the output is calibrated at 10mV/°K.

Precautions should be taken to ensure good sensing accuracy. As in the case of all temperatures sensors, self-heating can decrease accuracy. The LM135, LM235, and LM335 should operate with a low current but sufficient to drive the sensor and its calibration circuit to their maximum operating temperature.

If the sensor is used in surroundings where the thermal resistance is constant, the errors due to self-heating can be externally calibrated. This is possible if the circuit is biased with a temperature stable current. Heating will then be proportional to Zener voltage and therefore temperature. In this way, the error due to self-heating is proportional to the absolute temperature as scale factor errors.

Typical applications



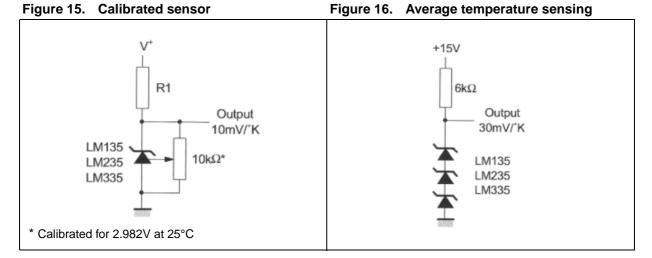
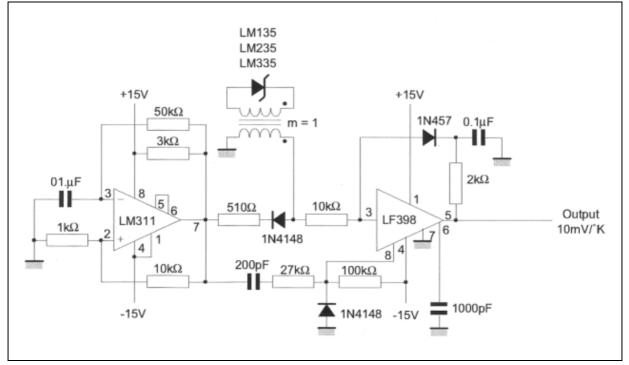


Figure 17. Isolated temperature sensor





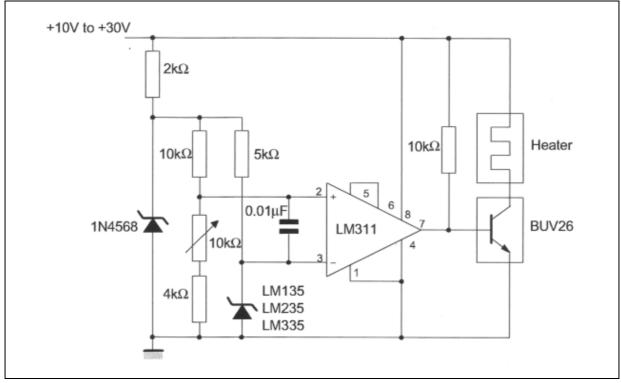
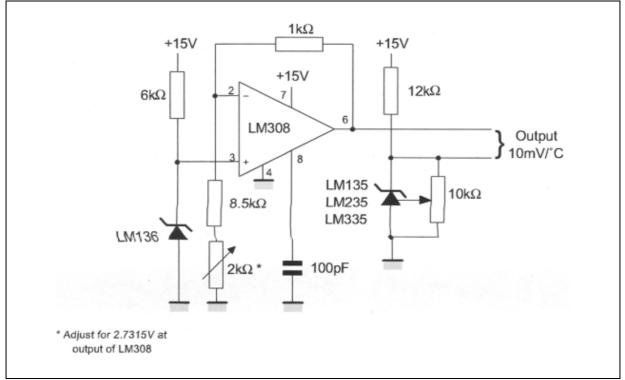


Figure 19. Centigrade thermometer





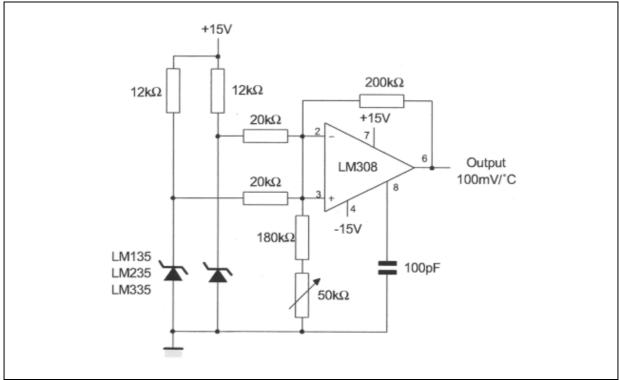
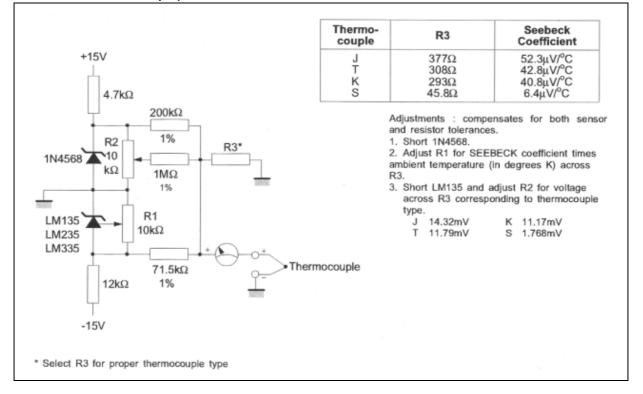


Figure 21. Thermocouple cold junction compensation (compensation for grounded thermocouple)



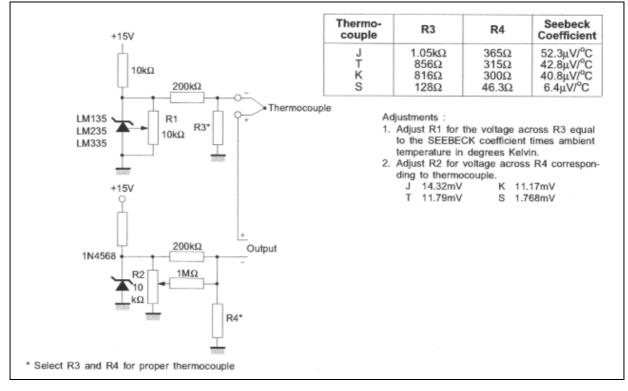


Figure 22. Single power supply cold junction compensation



6 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK[®] packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: <u>www.st.com</u>.

6.1 TO-92 tape & reel package information

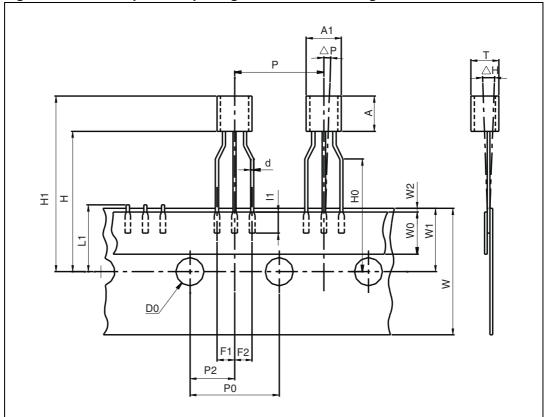


Figure 23. TO-92 tape & reel package mechanical drawing



able 4. IO-92 tape & reel package mechanical data							
Dim		Millimeters		Inches			
Dim.	Min.	Тур.	Max.	Min.	Тур.	Max.	
AL			5.0			0.197	
А			5.0			0.197	
Т			4.0			0.157	
d		0.45			0.018		
11	2.5			0.098			
Р	11.7	12.7	13.7	0.461	0.500	0.539	
PO	12.4	12.7	13	0.488	0.500	0.512	
P2	5.95	6.35	6.75	0.234	0.250	0.266	
F1/F2	2.4	2.5	2.8	0.094	0.098	0.110	
Δh	-1	0	1	-0.039	0	0.039	
ΔP	-1	0	1	-0.039	0	0.039	
W	17.5	18.0	19.0	0.689	0.709	0.748	
W0	5.7	6	6.3	0.224	0.236	0.248	
W1	8.5	9	9.75	0.335	0.354	0.384	
W2			0.5			0.020	
Н			20			0.787	
HO	15.5	16	16.5	0.610	0.630	0.650	
H1			25			0.984	
DO	3.8	4.0	4.2	0.150	0.157	0.165	
L1			11			0.433	

 Table 4.
 TO-92 tape & reel package mechanical data



6.2 TO-92 bulk package information



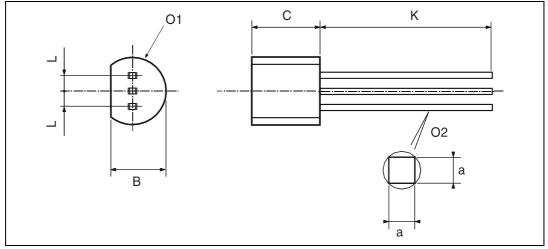


Table 5. TO-92	bulk package mec	hanical data
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Dim	Millimeters					
Dim.	Min.	Тур.	Max.	Min.	Тур.	Max.
L		1.27			0.05	
В	3.2	3.7	4.2	0.126	0.1457	0.1654
O1	4.45	5.00	5.2	0.1752	0.1969	0.2047
С	4.58	5.03	5.33	0.1803	0.198	0.2098
K	12.7			0.5		
O2	0.407	0.5	0.508	0.016	0.0197	0.02
а	0.35			0.0138		



6.3 SO-8 package information



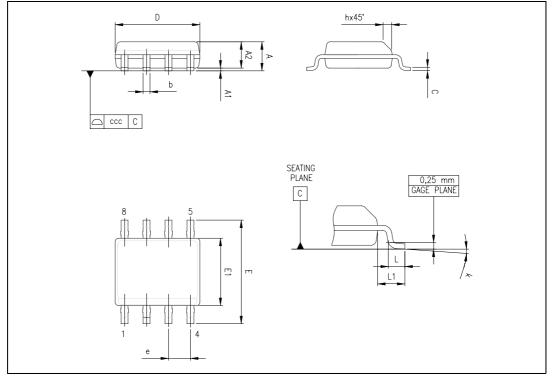


Table 6.SO-8 package mechanical data

			Dime	nsions		
Ref.		Millimeters			Inches	
	Min.	Тур.	Max.	Min.	Тур.	Max.
А			1.75			0.069
A1	0.10		0.25	0.004		0.010
A2	1.25			0.049		
b	0.28		0.48	0.011		0.019
с	0.17		0.23	0.007		0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
Н	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
е		1.27			0.050	
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	1°		8°	1°		8°
CCC			0.10			0.004



7 Ordering information

Order code	Temperature range	Package	Packing	Marking	
LM135Z	-55°C to +150°C	TO-92	Bulk	LM135	
LM235D LM235DT	-40°C to +125°C	SO-8	Tube or Tape & reel	LM235	
LM235Z	-40°C to +125°C	TO-92	Bulk	LM235	
LM335D LM335DT	40°C to +100°C	SO-8	Tube or	LM335	
LM335AD LM335ADT	40 C t0 +100 C	30-8	Tape & reel	LM335A	
LM335Z			Bulk	LM335	
LM335AZ LM335AZT	-40°C to +100°C	TO-92	Bulk or Tape & reel	LM335A	

Table 7. Order codes

8 Revision history

Table 8.	Document	revision	history
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Date	Revision	Changes
6-May-2003	1	Initial release.
13-April-2004	2	Corrected error in pinout diagram for TO-92 package on cover page (it is a bottom view, not a top view).
11-Feb-2007	3	Updated Section 6: Package information and Table 7: Order codes. Corrected typical values for uncalibrated temperature error in Table 2. Improved quality of electrical characteristics curves.

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