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Jameco Part Number 1992419



LM135 LM235 - LM335,A

PRECISION TEMPERATURE SENSORS

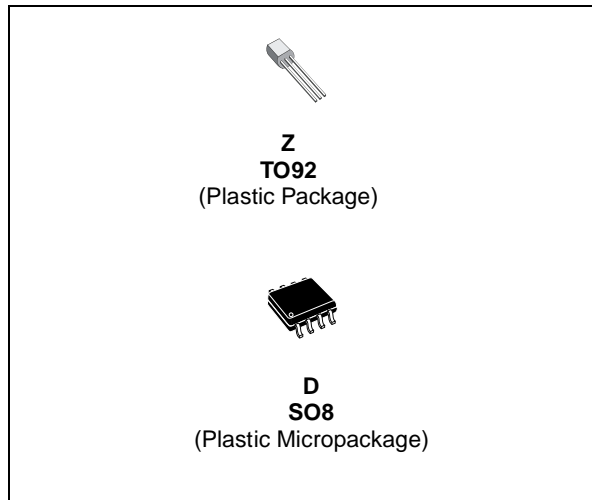
- DIRECTLY CALIBRATED IN K
- 1 C INITIAL ACCURACY
- OPERATES FROM 450µA TO 5mA
- LESS THAN 1Ω DYNAMIC IMPEDANCE

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 450µA to 5mA without alteration of its characteristics.

Calibrated at +25 C, the LM135, LM235, 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.

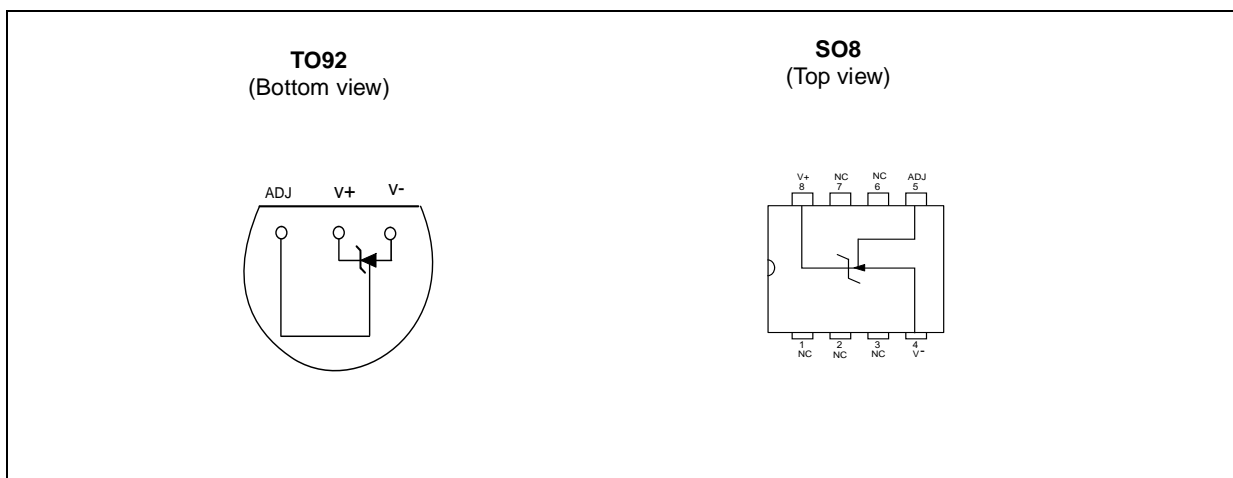


ORDER CODE

| Part Number | Temperature Range | Package | |
|-------------|-------------------|---------|---|
| | | Z | D |
| LM135 | -55 C, +150 C | • | • |
| LM235 | -40 C, +125 C | • | • |
| LM335,A | -40 C, +100 C | • | • |

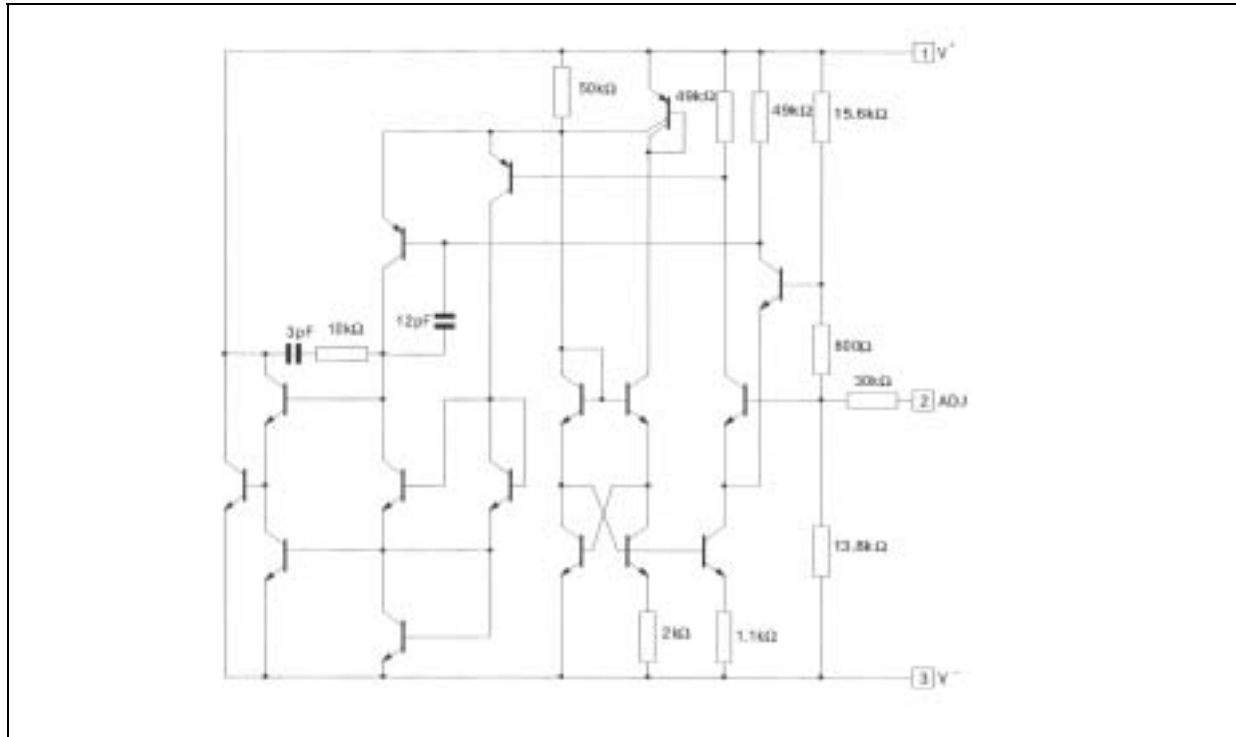
Z = TO92 Plastic package - also available in Bulk (Z), Tape & Reel (ZT) and Ammo Pack (AP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)

PIN CONNECTIONS



LM135 - LM235 - LM335,A

SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | LM135 | LM235 | LM335,A | 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. $T_J \leq 150$ C

TEMPERATURE ACCURACY

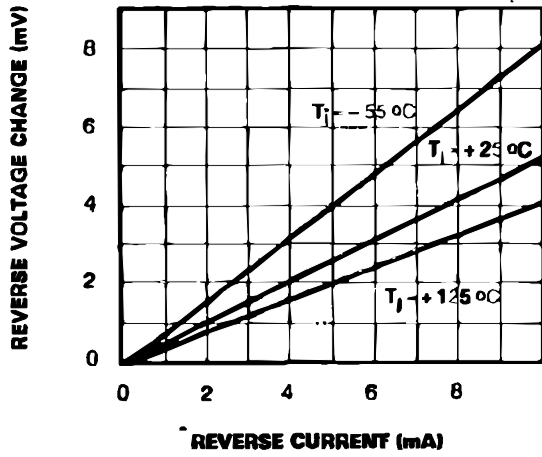
| Parameter | LM135 - LM235 - LM335A | | | LM335 | | | Unit |
|---|------------------------|--------|--------|-------|--------|--------|------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Operating Output Voltage $T_{case} = +25\text{ C}, I_R = 1\text{ mA}$ | 2.95 | 2.98 | 3.01 | 2.92 | 2.98 | 3.04 | V |
| Uncalibrated Temperature Error ($I_R = 1\text{ mA}$) $T_{case} = +25\text{ C}$ $T_{min.} \leq T_{case} \leq T_{max.}$ | | 1 2 | 3 5 | | 5 4 | 6 9 | C |
| Temperature Error with 25 C Calibration $T_{min.} \leq T_{case} \leq T_{max.}, I_R = 1\text{ mA}$ | | | | | | | |
| | | 0.5 | 1.5 | | 1 | 2 | C |
| | | 0.5 | 1 | | | | |
| Calibrated Error at Extended Temperature $T_{case} = T_{max.}$ (intermittent) | | 2 | | | 2 | | C |
| Non-linearity ($I_R = 1\text{ mA}$) | | | | | | | |
| | LM135 - LM235 | 0.3 | 1 | | | | C |
| | LM335 | | | | 0.3 | 1.5 | |
| | LM335A | 0.3 | 1.5 | | | | |

ELECTRICAL CHARACTERISTICS - (note 1)

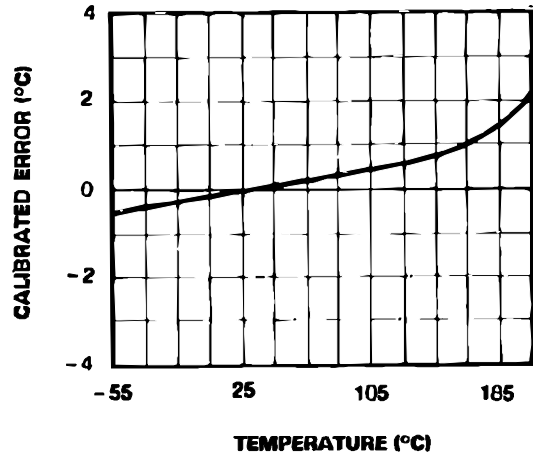
| Parameter | LM135 - LM235 | | | LM335,A | | | Unit |
|--|---------------|------|------|---------|------|------|----------|
| | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Operating output voltage change with current $450\mu\text{A} \leq I_R \leq 5\text{ mA}$ at constant temperature | | 2.5 | 10 | | 3 | 14 | mV |
| Dynamic Impedance ($I_R = 1\text{ mA}$) | | 0.5 | | | 0.6 | | Ω |
| Output Voltage Temperature Drift | | +10 | | | +10 | | mV/ C |
| Time Constant | | | | | | | |
| | Still Air | 80 | | | 80 | | |
| | Air 0.5m/s | 10 | | | 10 | | s |
| | Stirred Oil | 1 | | | 1 | | |
| Time Stability ($T_{case} = +125\text{ C}$) | | 0.2 | | | 0.2 | | C/kh |

1. Accuracy measurements are made in a well-stirred oil bath. For other conditions, self heating must be considered

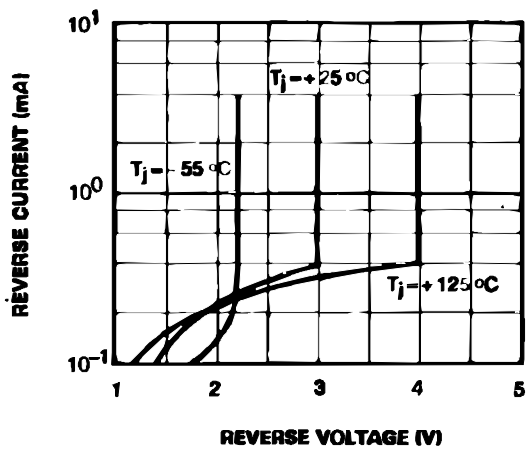
REVERSE VOLTAGE CHANGE



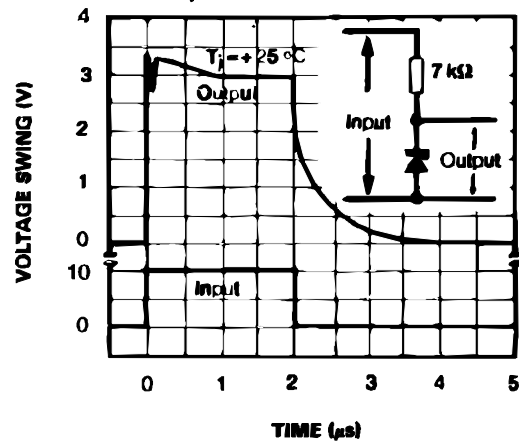
CALIBRATED ERROR



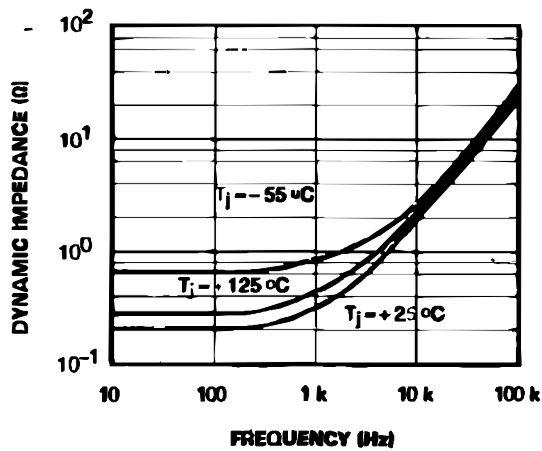
REVERSE CHARACTERISTICS



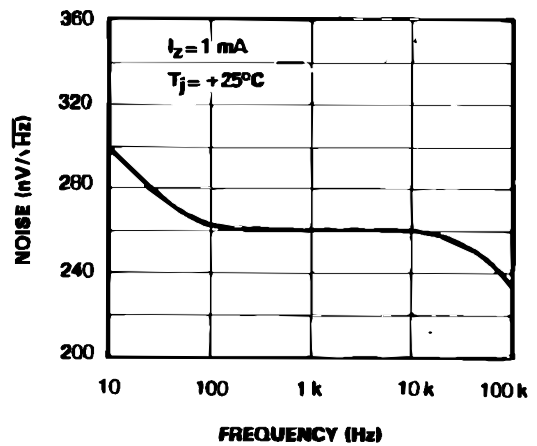
RESPONSE TIME



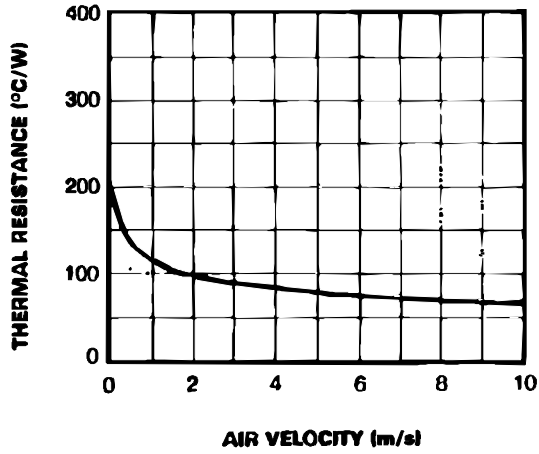
DYNAMIC IMPEDANCE



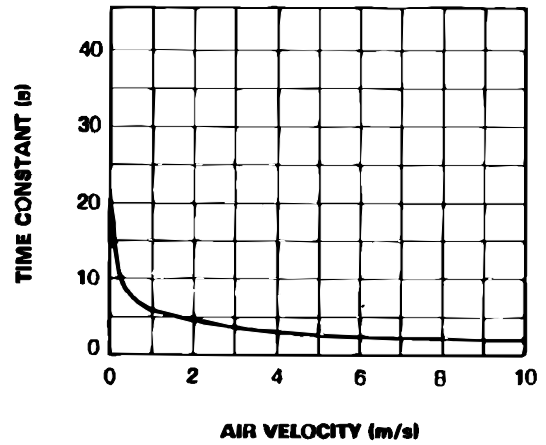
NOISE VOLTAGE



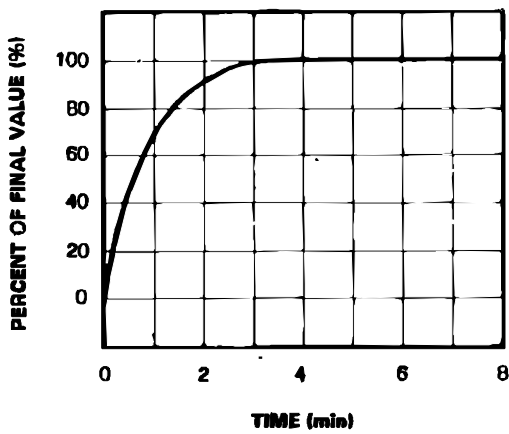
THERMAL RESISTANCE JUNCTION TO AIR



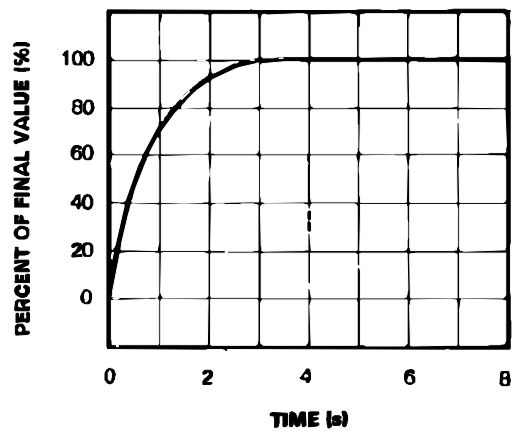
THERMAL TIME CONSTANT



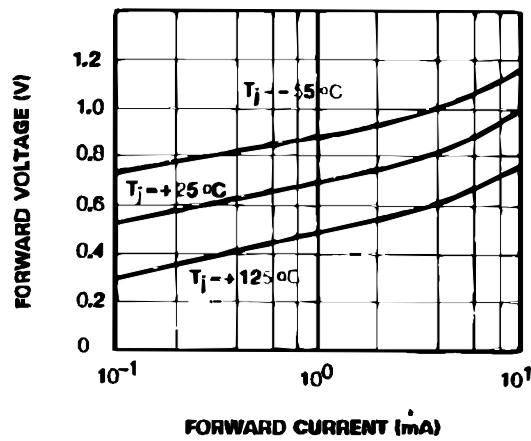
THERMAL RESPONSE IN STILL AIR



THERMAL RESPONSE IN STIRRED OIL BATH



FORWARD CHARACTERISTICS



APPLICATION HINTS

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) can be given by the equation: $V_{OT} + V_{OTO} \times \frac{T}{T_o}$

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

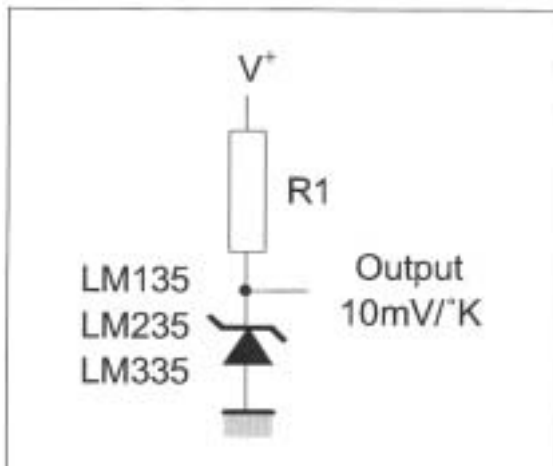
Nominally the output is calibrated at 10mV/ K.

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, LM335 should operate with a low current but sufficient to drive the sensor and its calibration circuit to their maximum operating temperature.

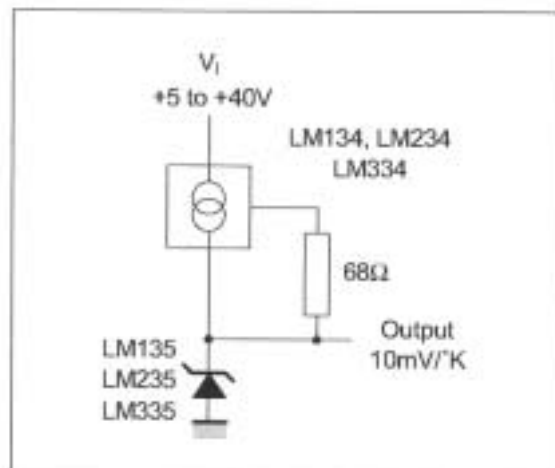
If the sensor is used in surroundings where the thermal resistance is constant, the errors due to self heating can be externally calibrated. This is possible if the circuit is biased with a temperature stable current. Heating will then be proportional to zener voltage and therefore temperature. In this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

TYPICAL APPLICATIONS

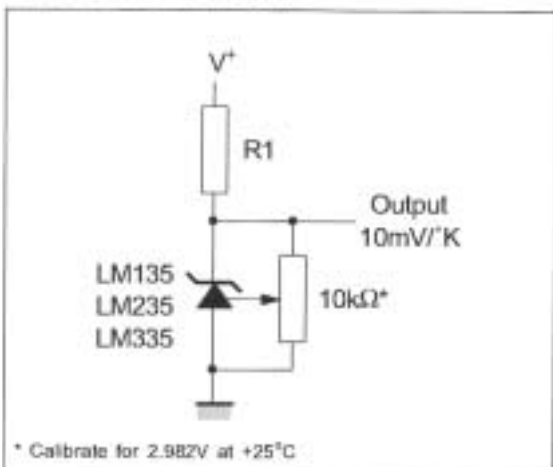
BASIC TEMPERATURE SENSOR



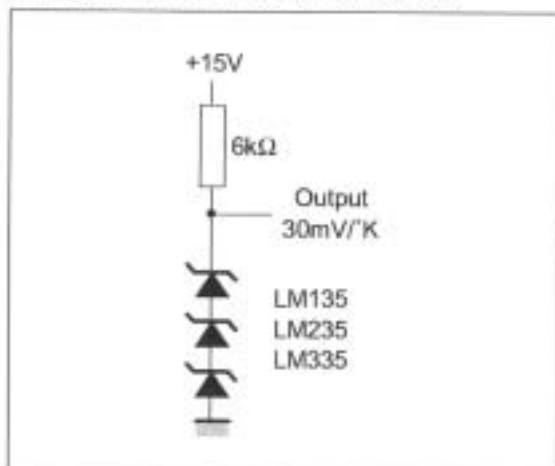
WIDE OPERATING SUPPLY



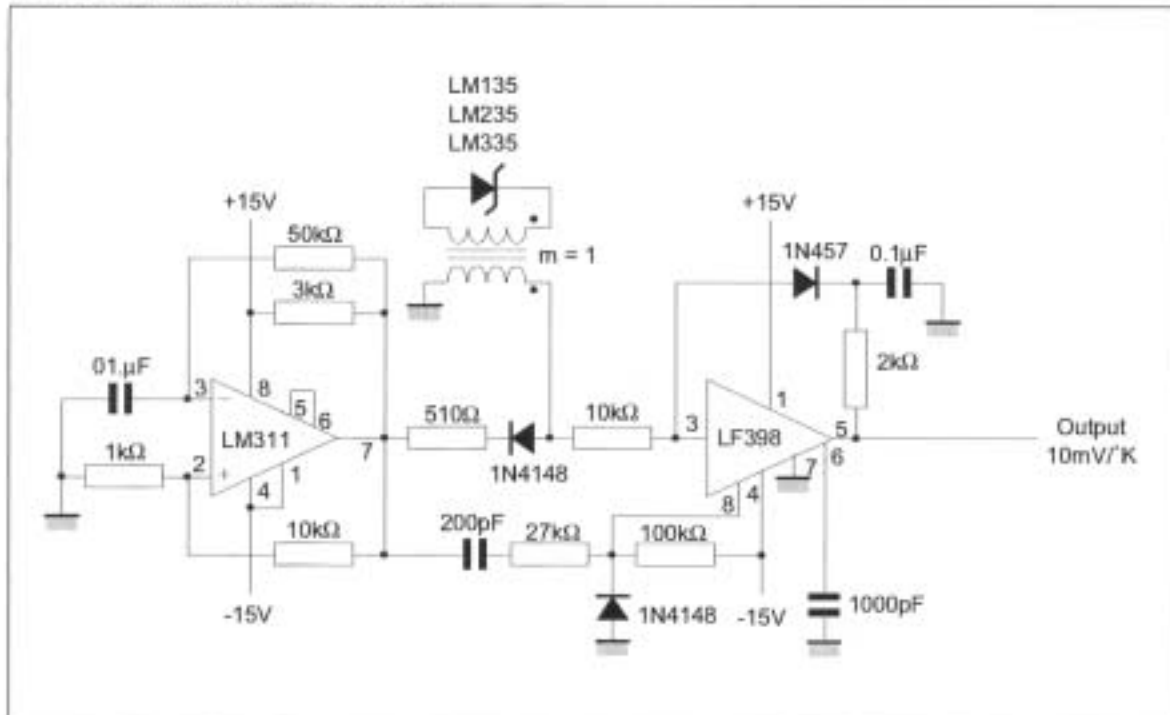
CALIBRATED SENSOR



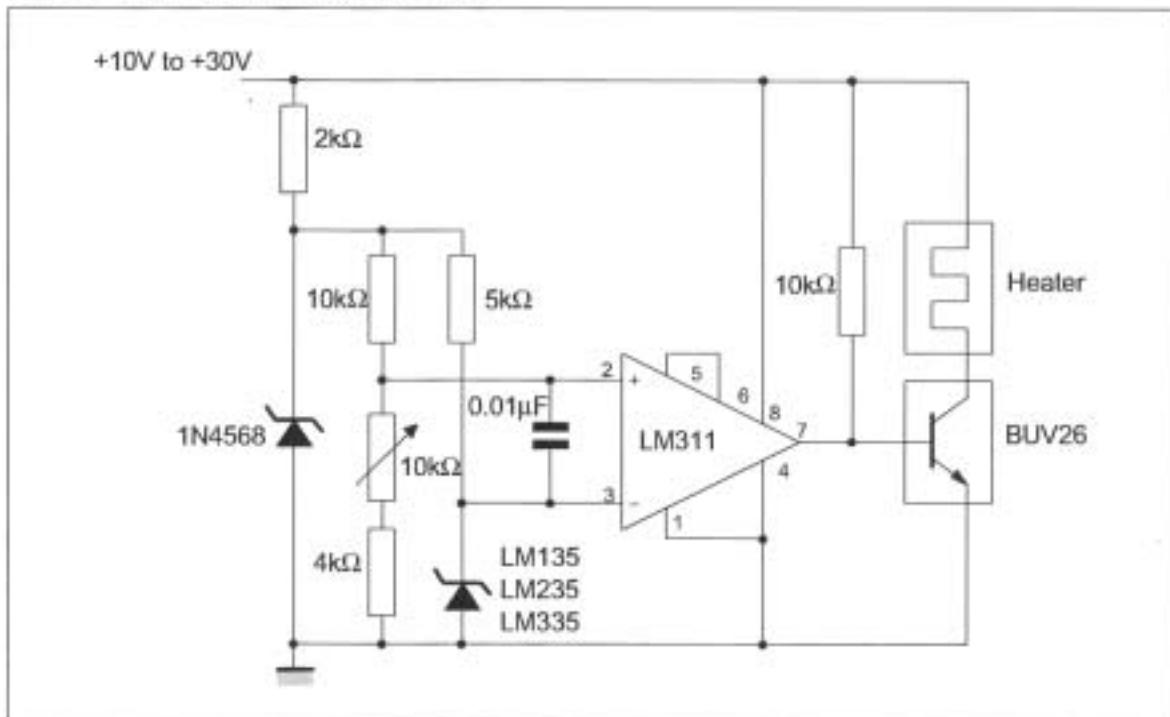
AVERAGE TEMPERATURE SENSING



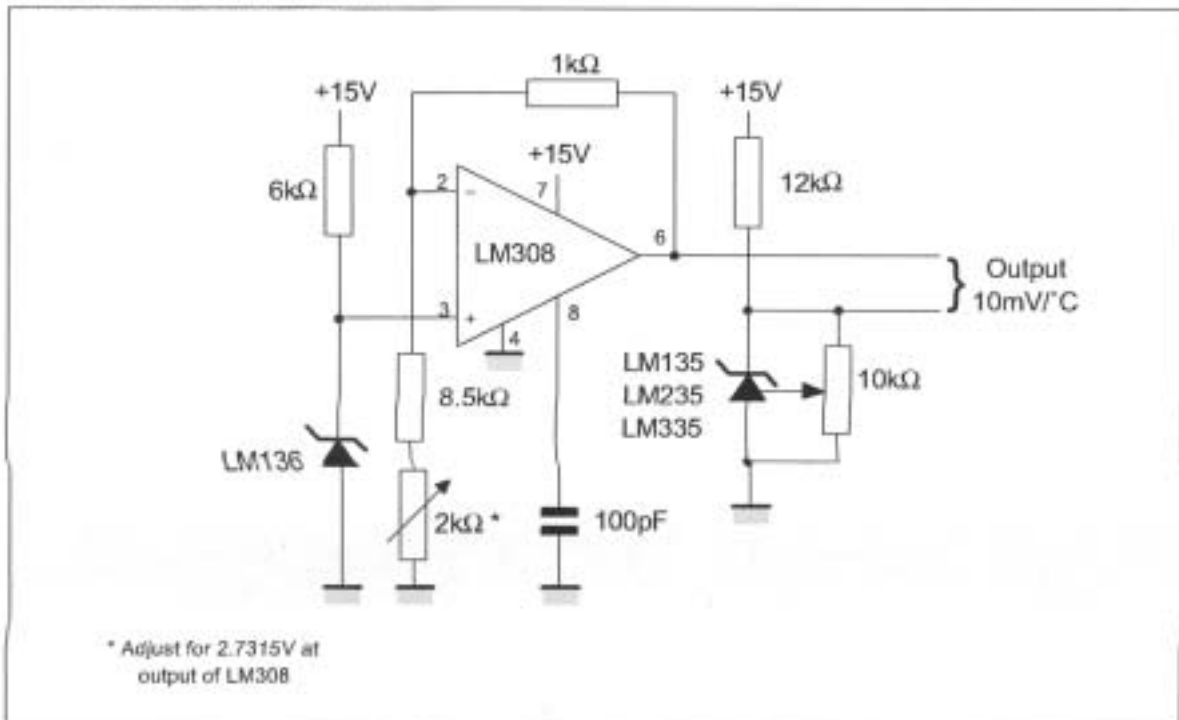
ISOLATED TEMPERATURE SENSOR



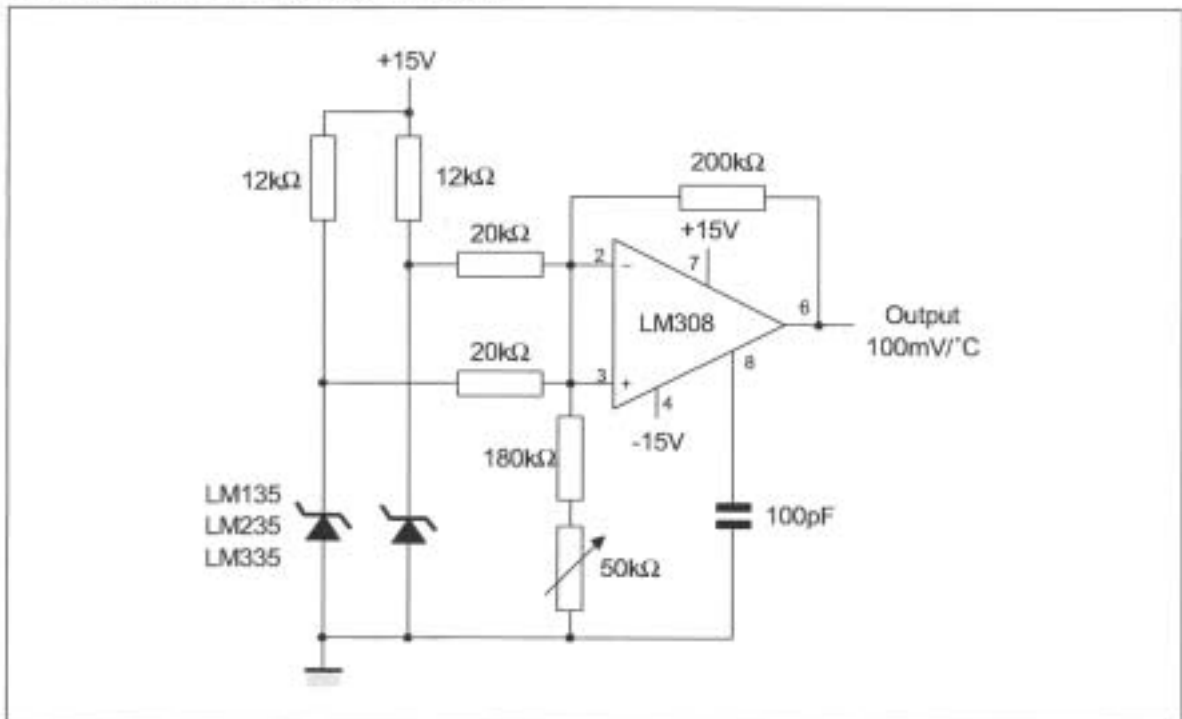
SIMPLE TEMPERATURE CONTROLLER



CENTIGRADE THERMOMETER



DIFFERENTIAL TEMPERATURE SENSOR



THERMOCOUPLE COLD JUNCTION COMPENSATION
(compensation for grounded thermocouple)

| Thermo-couple | R3 | Seebeck Coefficient |
|---------------|-------|---------------------|
| J | 377Ω | 52.3μV/°C |
| T | 308Ω | 42.8μV/°C |
| K | 293Ω | 40.8μV/°C |
| S | 45.8Ω | 6.4μV/°C |

Adjustments : compensates for both sensor and resistor tolerances.

- Short 1N4568.
- Adjust R1 for SEEBECK coefficient times ambient temperature (in degrees K) across R3.
- Short LM135 and adjust R2 for voltage across R3 corresponding to thermocouple type.

| | | | |
|---|---------|---|---------|
| J | 14.32mV | K | 11.17mV |
| T | 11.79mV | S | 1.768mV |

* Select R3 for proper thermocouple type

SINGLE POWER SUPPLY COLD JUNCTION COMPENSATION

| Thermo-couple | R3 | R4 | Seebeck Coefficient |
|---------------|--------|-------|---------------------|
| J | 1.05kΩ | 365Ω | 52.3μV/°C |
| T | 856Ω | 315Ω | 42.8μV/°C |
| K | 816Ω | 300Ω | 40.8μV/°C |
| S | 128Ω | 46.3Ω | 6.4μV/°C |

Adjustments :

- Adjust R1 for the voltage across R3 equal to the SEEBECK coefficient times ambient temperature in degrees Kelvin.
- Adjust R2 for voltage across R4 corresponding to thermocouple.

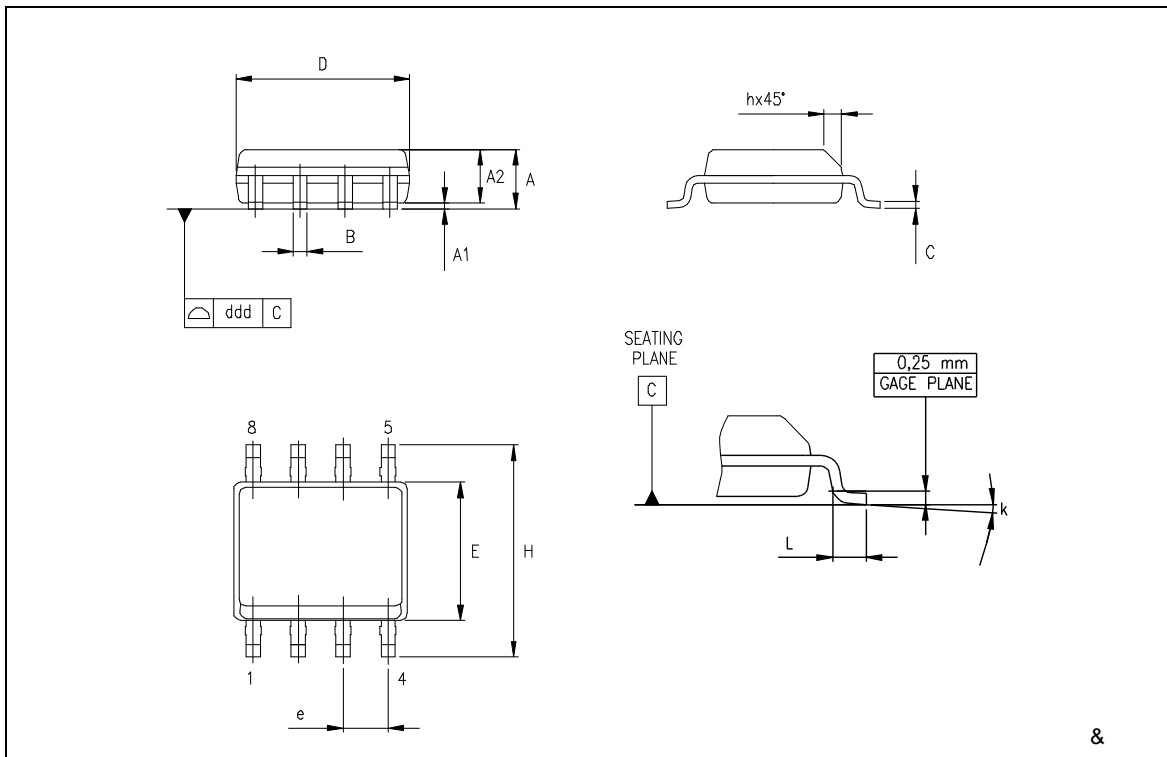
| | | | |
|---|---------|---|---------|
| J | 14.32mV | K | 11.17mV |
| T | 11.79mV | S | 1.768mV |

* Select R3 and R4 for proper thermocouple

PACKAGE MECHANICAL DATA

62 0 (&+\$1,&\$/ ' \$7\$

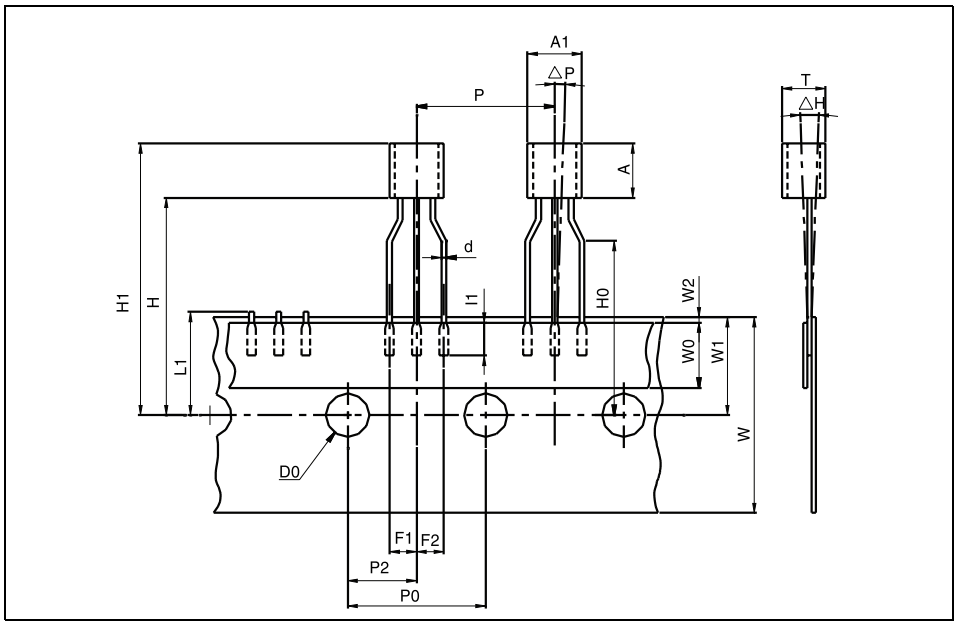
| ',0 | PP | | | LQK | | |
|-----|-------|-----|------|-----|-----|------|
| | 0,1 | 7<3 | 0\$; | 0,1 | 7<3 | 0\$; |
| \$ | | | | | | |
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PACKAGE MECHANICAL DATA - TO92 TAPE AMMO PACK & TO92 TAPE & REEL

TO-92 MECHANICAL DATA

| DIM. | mm. | | | inches | | |
|-------|------|------|------|--------|-------|-------|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| AL | | | 5.0 | | | 0.197 |
| A | | | 5.0 | | | 0.197 |
| T | | | 4.0 | | | 0.157 |
| d | | 0.45 | | | 0.018 | |
| l1 | 2.5 | | | 0.098 | | |
| P | 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 |
| h | -1 | 0 | 1 | -0.039 | 0 | 0.039 |
| P | -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 |
| H | | | 20 | | | 0.787 |
| H0 | 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 |



Packing information are available at: <http://www.st.com/stonline/prodpres/packages/stdlin.htm>

PACKAGE MECHANICAL DATA - TO92 BULK

| 72 0(&+\$1,& '\$7\$ | | | | | | |
|----------------------|-----|-----|------|-----|-----|------|
| '0 | PP | | | PLØ | | |
| | 0,1 | 7<3 | 0\$; | 0,1 | 7<3 | 0\$; |
| \$ | | | | | | |
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The diagram shows three views of a TO92 package. The top view shows a circular lead with radius R and diameter D . The side view shows the package height L and lead width W . A detail view shows the lead thickness $e1$ and diameter e . Another side view shows the package height A and lead diameter b . The ST logo is present in the bottom right corner of the diagram area.

Packing information are available at: <http://www.st.com/stonline/prodpres/packages/stdlin.htm>

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