

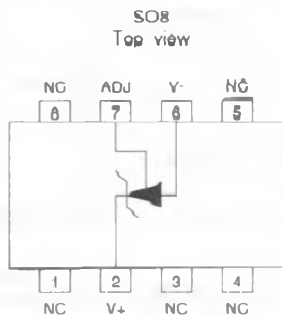
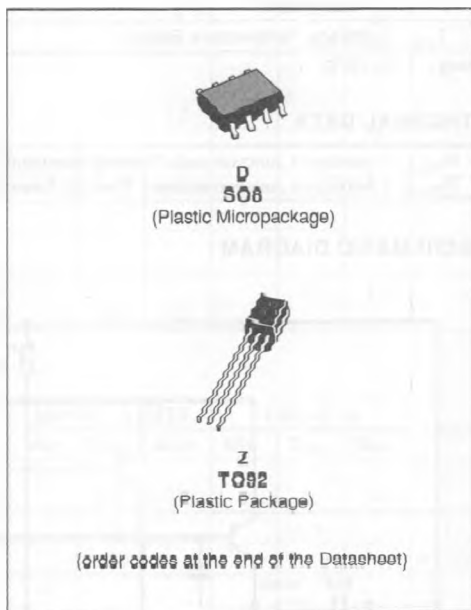
PRECISION TEMPERATURE SENSORS

- DIRECTLY CALIBRATED IN °K
- 1 °C INITIAL ACCURACY
- OPERATES FROM 400 μ A TO 5 mA
- LESS THAN 1 Ω DYNAMIC IMPEDANCE

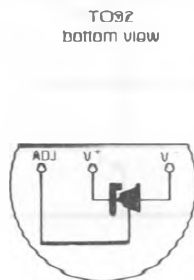
DESCRIPTION

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 10 mV/°K. The circuit has a dynamic impedance of less than 1 Ω and operates within a range of current from 400 μ A to 5 mA 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.

PIN CONNECTION



E66LM135-01



E66LM135-02

ABSOLUTE MAXIMUM RATINGS

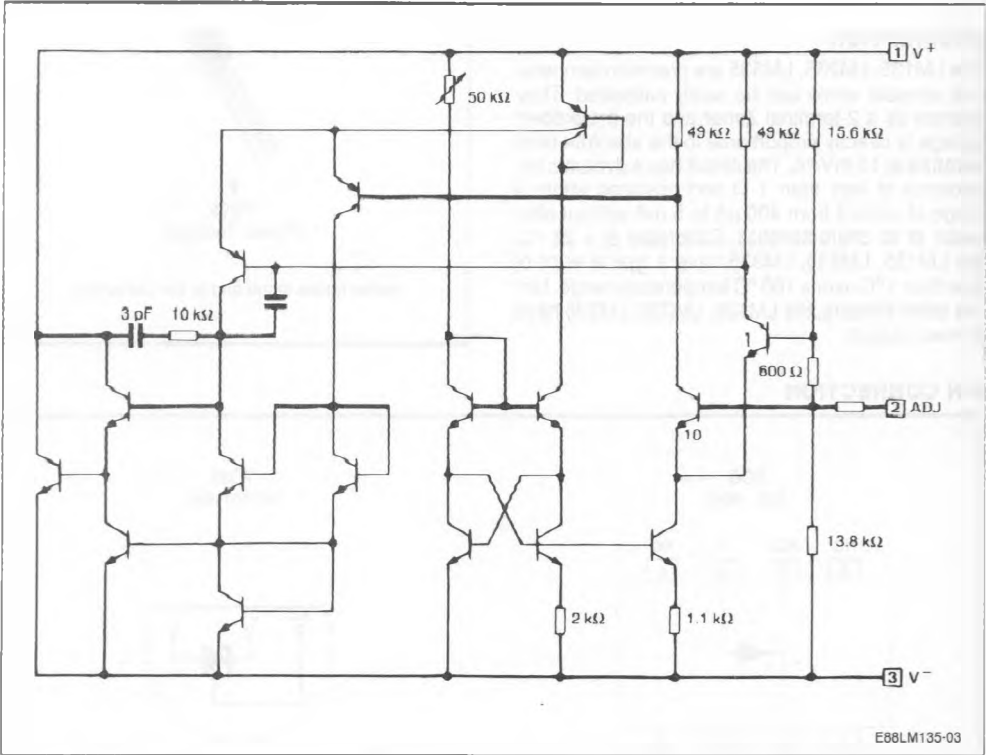
Symbol	Parameter	LM135	LM235	LM335, A	Unit
I_R I_F	Current Reverse Foward	15 10	15 10	15 10	mA
T_{oper}	Operating Free-air Temperature Range (note 1) Continuous Intermittent	- 55 to + 150 + 150 to + 200	- 40 to + 125 + 125 to + 150	- 40 to + 100 + 100 to + 125	°C
T_{stg}	Storage Temperature Range	- 65 to + 150	- 65 to + 150	- 65 to + 150	°C

Note : 1. $T_I \leq 150^\circ\text{C}$.

THERMAL DATA

$R_{th(j-c)}$	Maximum Junction-case Thermal Resistance	60	°C/W
$R_{th(j-a)}$	Maximum Junction-ambient Thermal Resistance	170	°C/W

SCHEMATIC DIAGRAM



TEMPERATURE ACCURACY

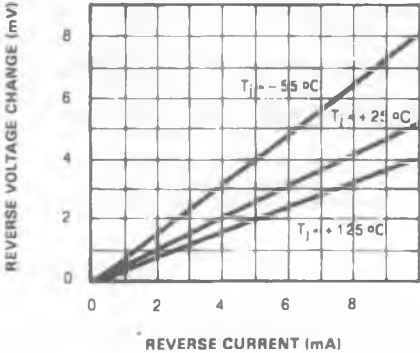
Symbol	Parameter	LM135 - LM235 LM335A			LM335			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
	Operating Output Voltage ($T_{case} = +25^{\circ}\text{C}$, $I_R = 1\text{ mA}$)	2.95	2.98	3.01	2.92	2.98	3.04	V
	Uncalibrated Temperature Error ($I_R = 1\text{ mA}$) $T_{case} = +25^{\circ}\text{C}$ $T_{(min)} < T_{case}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

ELECTRICAL CHARACTERISTICS (note 1)

Symbol	Parameter	LM135 - LM235			LM335, A			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
	Operating output voltage change with current ($400\text{ }\mu\text{A} < I_R < 5\text{ mA}$ 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/ $^{\circ}\text{C}$
	Time Constant Still Air Air 0.5 m/s Stirred Oil		80 10 1			80 10 1		s
	Time Stability ($T_{case} = +125^{\circ}\text{C}$)		0.2			0.2		$^{\circ}\text{C}/\text{kh}$

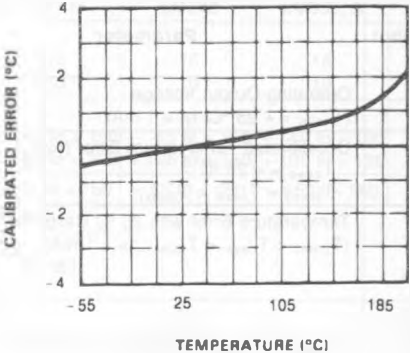
Note : 1. Accuracy measurements are made in a well-stirred oil bath. For other conditions, self heating must be considered.

REVERSE VOLTAGE CHANGE



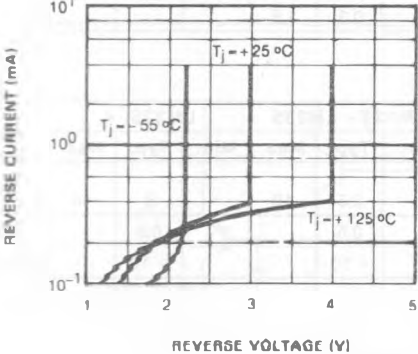
E88LM135-04

CALIBRATED ERROR



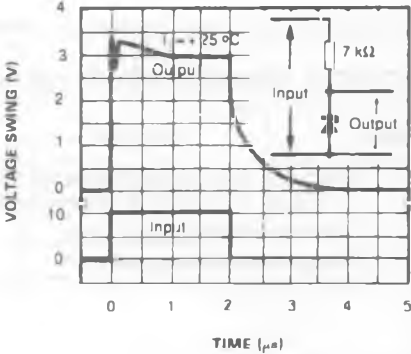
E88LM135-05

REVERSE CHARACTERISTICS



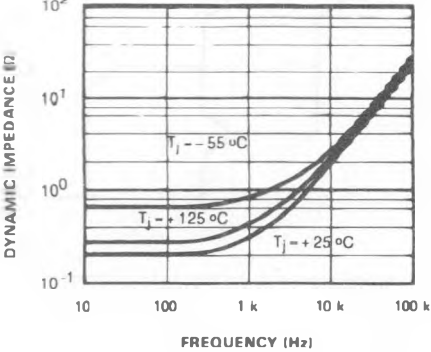
E88LM135-06

RESPONSE TIME



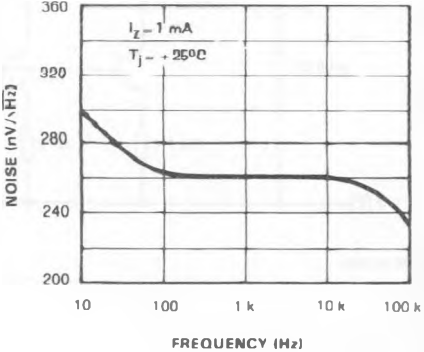
E88LM135-07

DYNAMIC IMPEDANCE



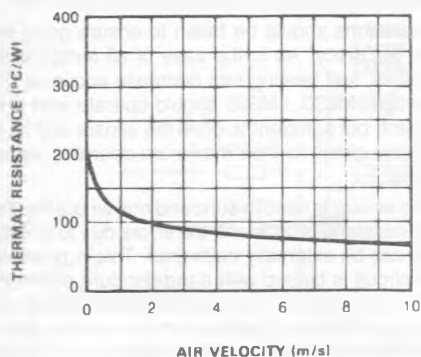
E88LM135-08

NOISE VOLTAGE



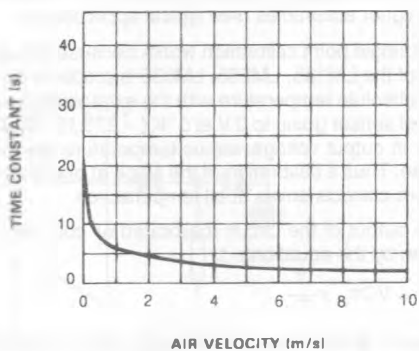
E88LM135-09

THERMAL RESISTANCE JUNCTION TO AIR



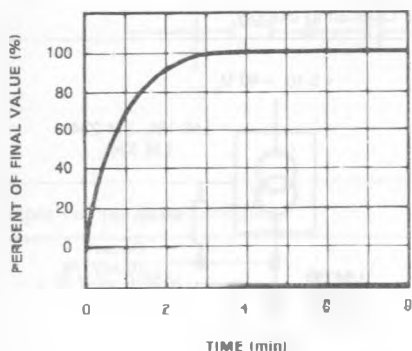
E88LM135-10

THERMAL TIME CONSTANT



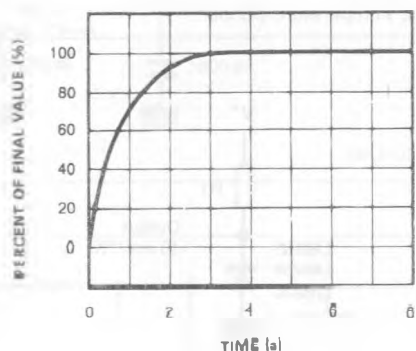
E88LM135-11

THERMAL RESPONSE IN STILL AIR



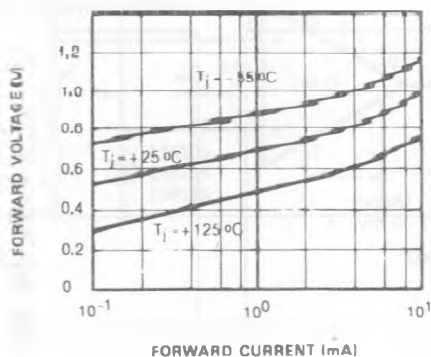
E88LM135-12

THERMAL RESPONSE IN STIRRED OIL BATH



E88LM135-13

FORWARD CHARACTERISTICS



E88LM135-14

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 0 V 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.

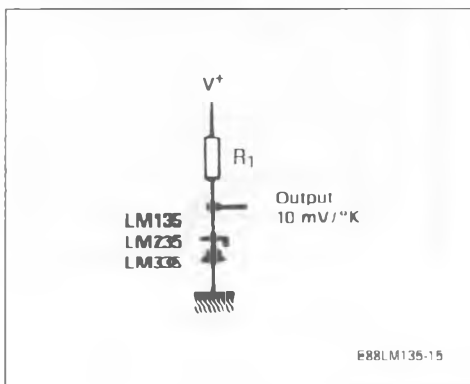
The output of the circuit (calibrated or not) can be given by the equation :

$$V_{OT} = V_{OT_0} \times \frac{T}{T_0}$$

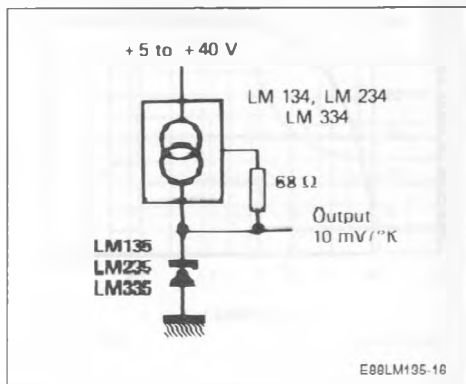
where T is the unknown temperature and T₀ is the reference temperature (in °K).

TYPICAL APPLICATIONS

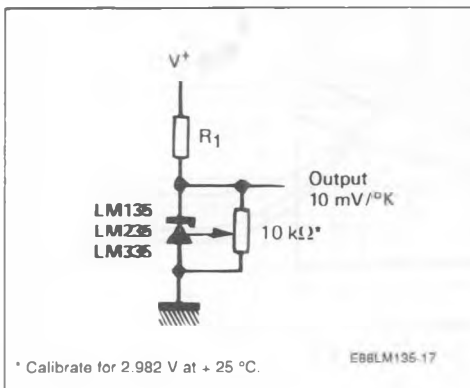
Basic Temperature Sensor.



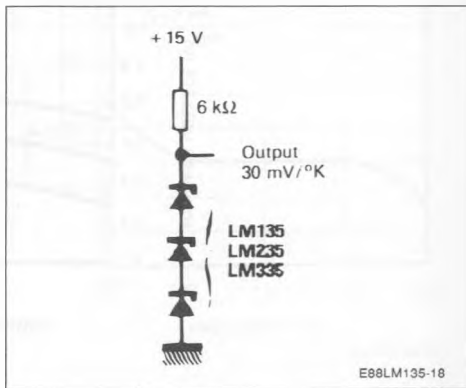
Wide Operating Supply.



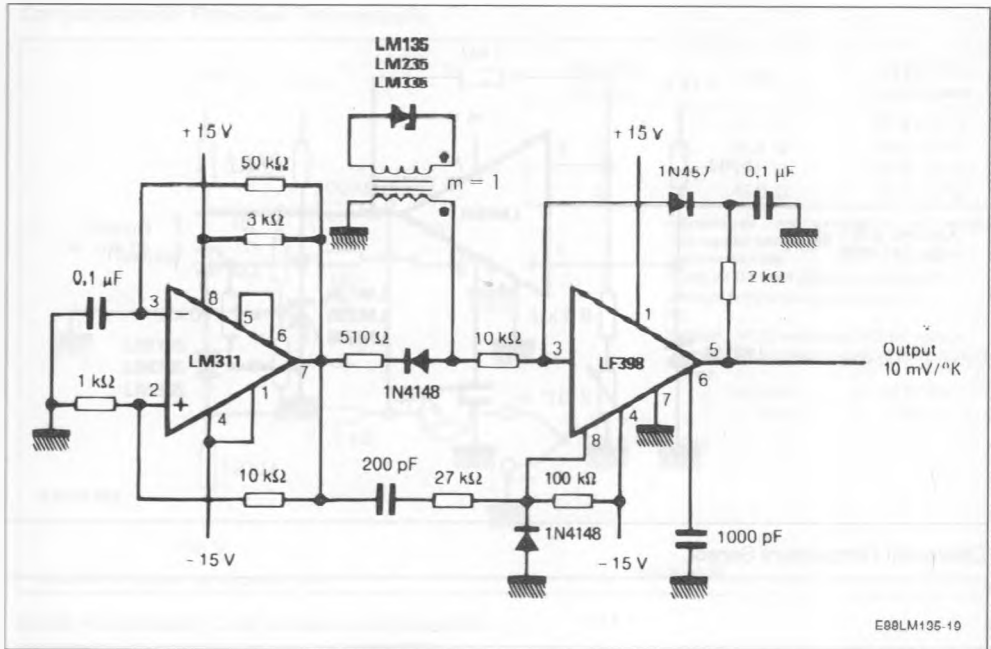
Calibrated Sensor.



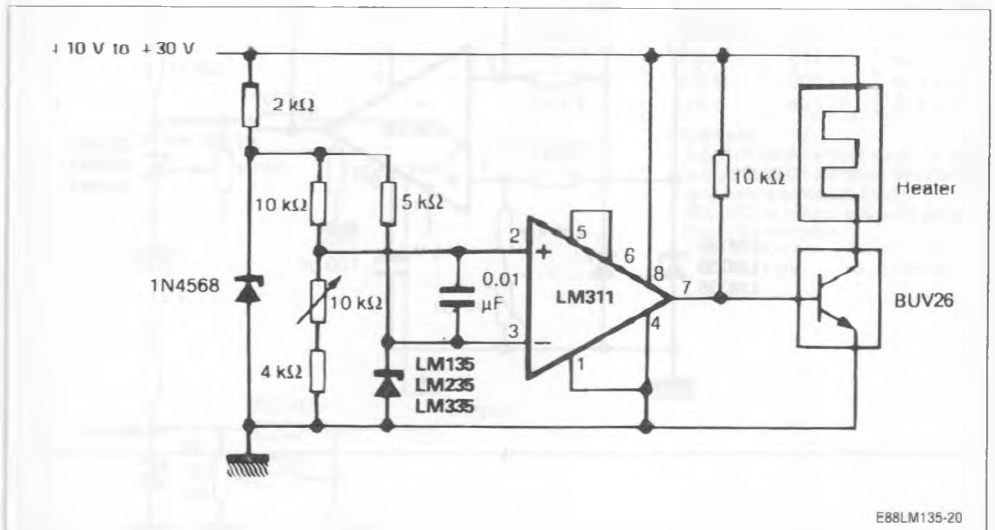
Average Temperature Sensing.



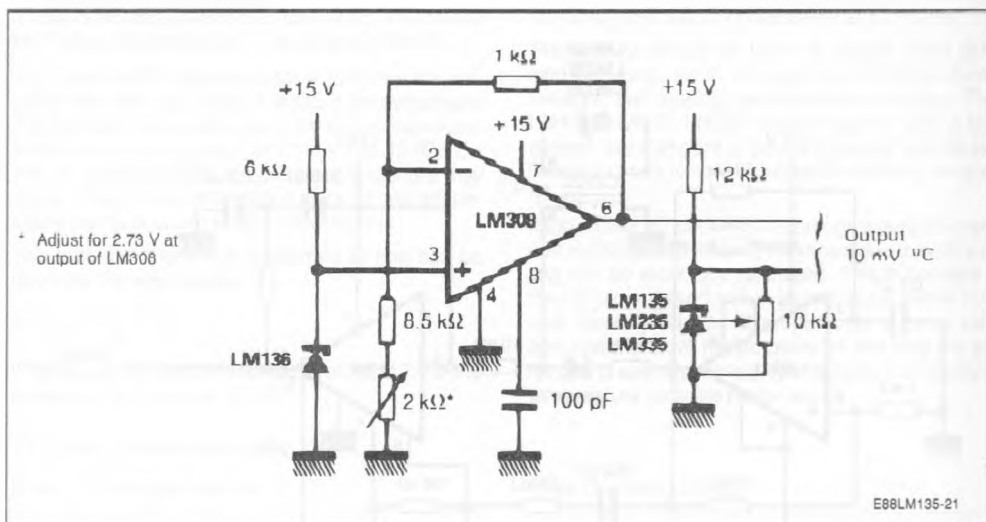
Isolated Temperature Sensor.



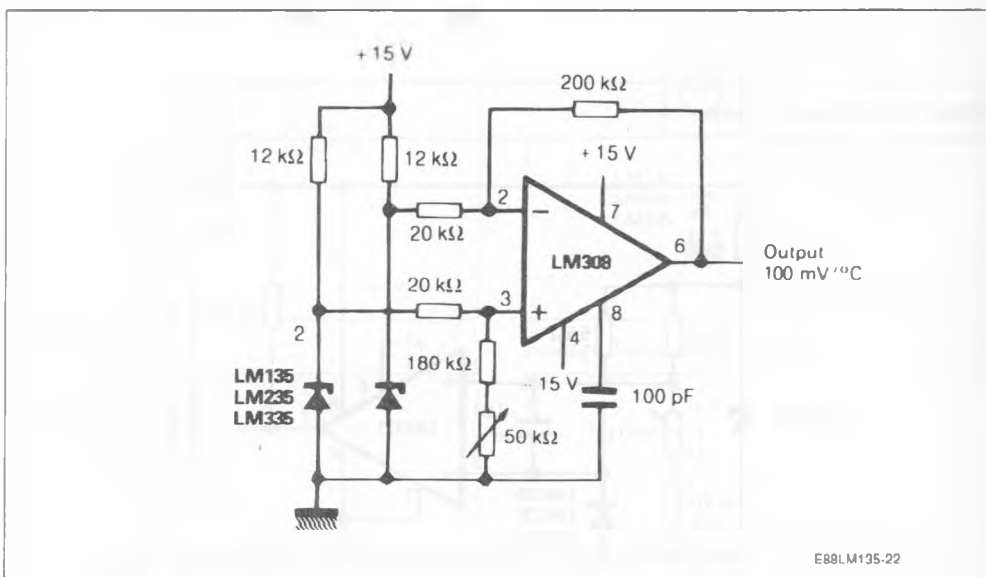
Simple Temperature Controller.



Centigrade Thermometer.

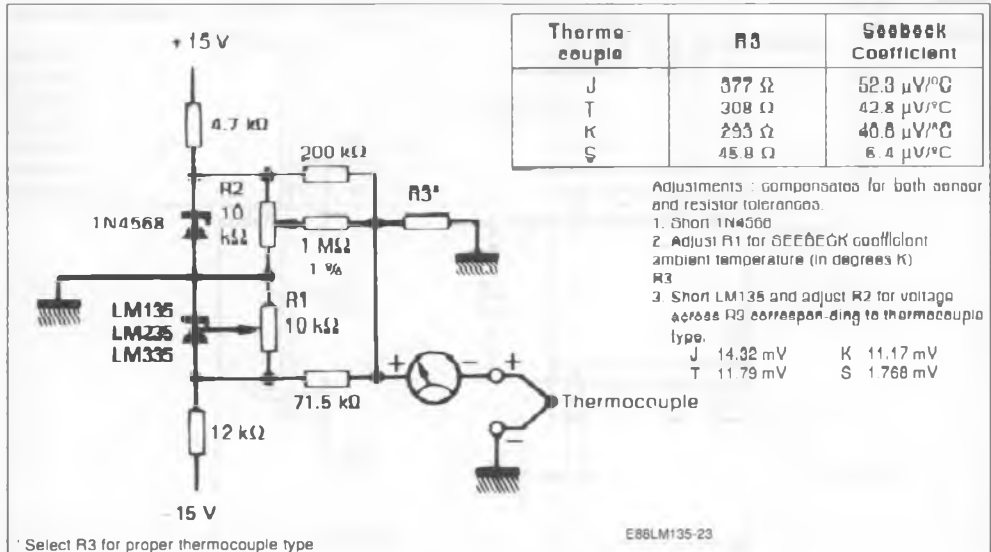


Differential Temperature Sensor.

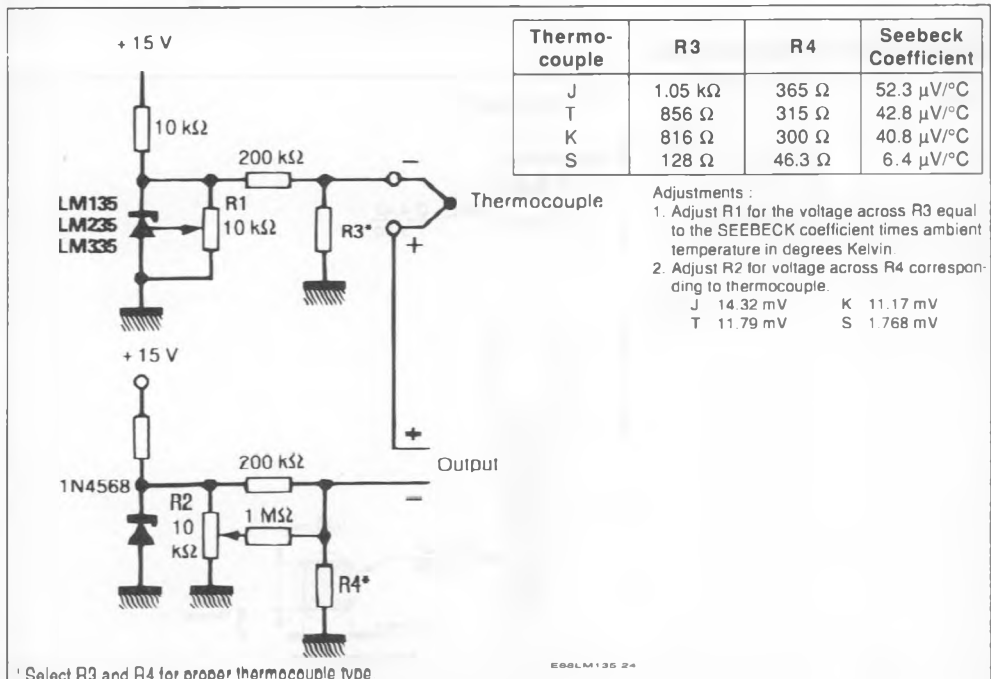


THERMOCOUPLE COLD JUNCTION COMPENSATION

Compensation for Grounded Thermocouple.

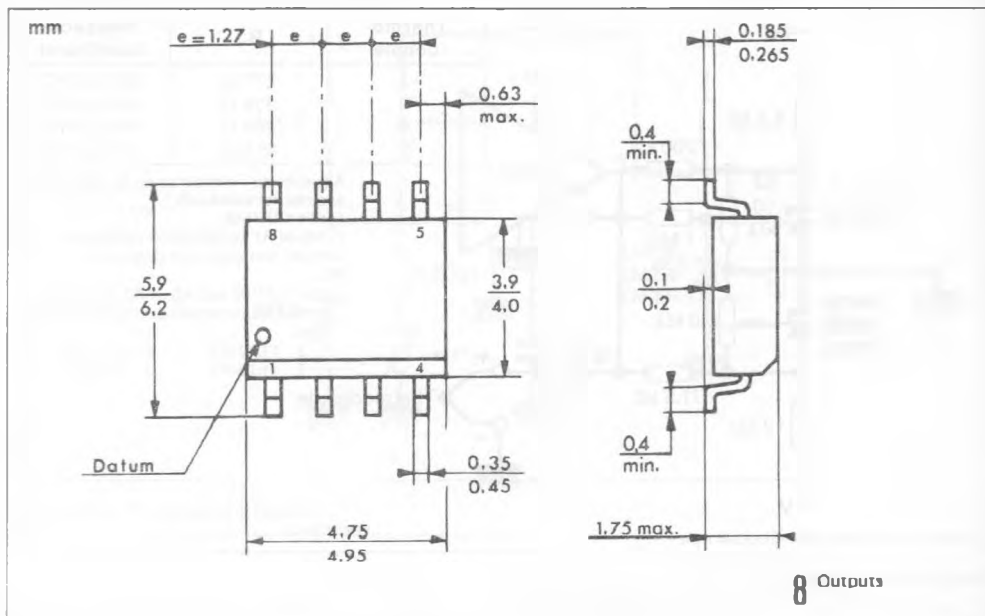


Single Power Supply Cold Junction Compensation.

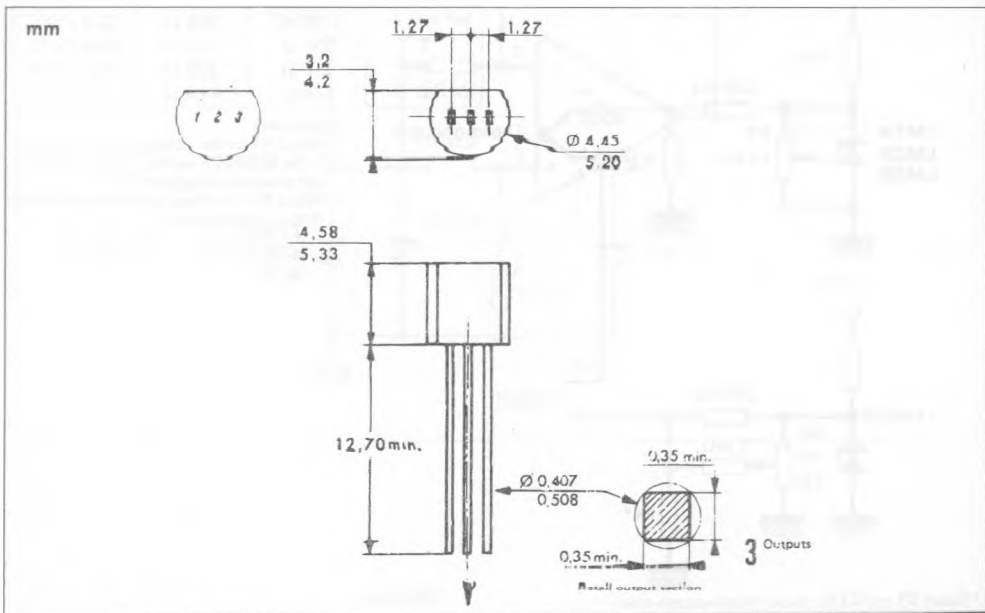


PACKAGE MECHANICAL DATA

8 PINS - PLASTIC MICROPACKAGE (SO)



3 PINS - PLASTIC PACKAGE TO92



ORDER CODES

Part number	Temperature Range		Package
	Continuous	Intermittent	
LM135Z	- 55 °C to + 150 °C	+ 150 °C to + 200 °C	TO92
LM235Z	- 40 °C to + 125 °C	+ 125 °C to + 150 °C	TO92
LM235D	- 40 °C to + 125 °C	+ 125 °C to + 150 °C	SO8
LM335Z	- 40 °C to + 100 °C	+ 100 °C to + 125 °C	TO92
LM335D	- 40 °C to + 100 °C	+ 100 °C to + 125 °C	SO8
LM335AZ	- 40 °C to + 100 °C	+ 100 °C to + 125 °C	TO92
LM335AD	- 40 °C to + 100 °C	+ 100 °C to + 125 °C	SO8