SGS-THOMSON MICROELECTRONICS

LM135
LM235-LM335,A

PRECISION TEMPERATURE SENSORS

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

D
SO8
(Plastic Micropackage)

Z
TO92
(Plastic Package)

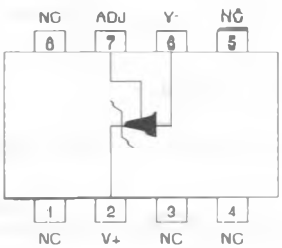
(order codes at the end of the Datasheet)

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 µA 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.

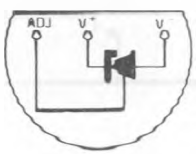
PIN CONNECTION

SO8
Top view



E66LM135-01

TO92
bottom view



E66LM135-02

ABSOLUTE MAXIMUM RATINGS

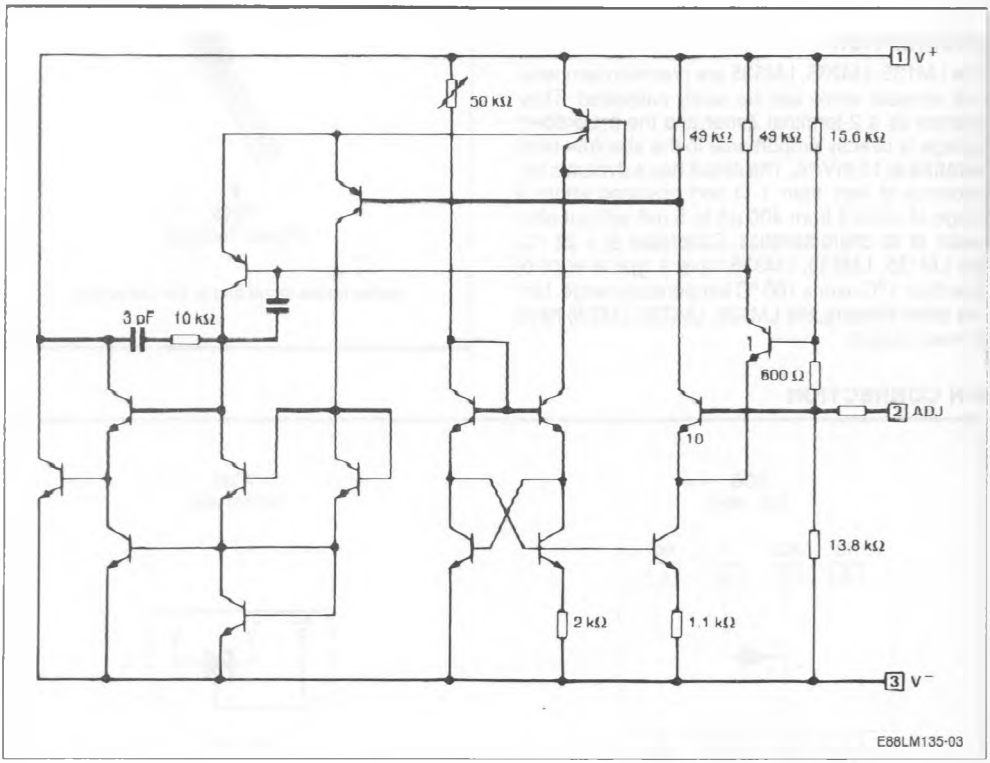
Symbol	Parameter	LM135	LM235	LM335, A	Unit
	Current				mA
I_R	Reverse	15	15	15	
I_F	Foward	10	10	10	
T_{oper}	Operating Free-air Temperature Range (note 1)				°C
	Continuous	− 55 to + 150	− 40 to + 125	− 40 to + 100	
	Intermittent	+ 150 to + 200	+ 125 to + 150	+ 100 to + 125	
T_{stg}	Storage Temperature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

Note : 1. $T_j \leq 150$ °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

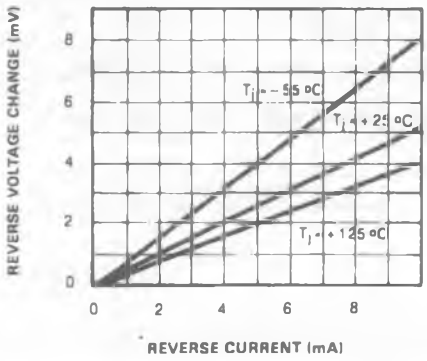
Symbol	Parameter	LM135 - LM235 LM335A			LM335			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
	Operating Output Voltage (T_{case} = + 25 °C, I_R = 1 mA)	2.95	2.98	3.01	2.92	2.98	3.04	V
	Uncalibrated Temperature Error (I_R = 1 mA)							°C
	T_{case} = + 25 °C		1	3		2	6	
	$T_{(min)} < T_{case} < T_{(max)}$		2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

ELECTRICAL CHARACTERISTICS (note 1)

Symbol	Parameter	LM135 - LM235			LM335, A			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
	Operating output voltage change with current (400 µA < I_R < 5 mA at constant temperature)		2.5	10		3	14	mV
	Dynamic Impedance (I_R = 1 mA)		0.5			0.6		Ω
	Output Voltage Temperature Drift		± 10			± 10		mV/°C
	Time Constant							s
	Still Air		80			80		
	Air 0.5 m/s		10			10		
	Stirred Oil		1			1		
	Time Stability (T_{case} = + 125 °C)		0.2			0.2		°C/kh

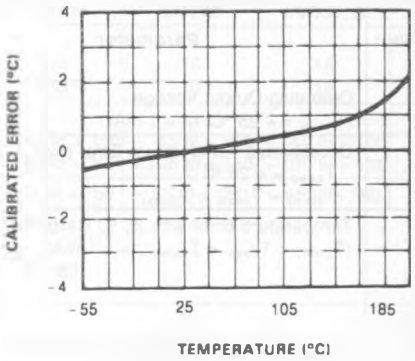
Note : 1. Accuracy measurements are made in a well-stirred oil bath. For other conditions, self heating must be considered.

REVERSE VOLTAGE CHANGE



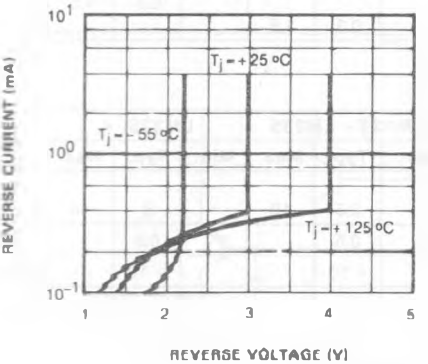
E88LM135-04

CALIBRATED ERROR



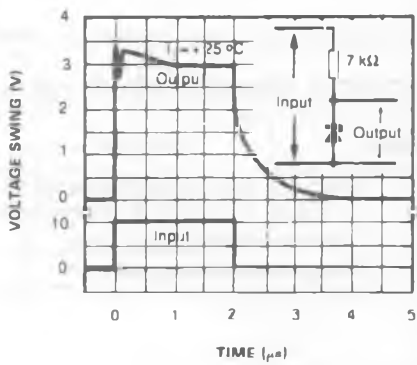
E88LM135-05

REVERSE CHARACTERISTICS



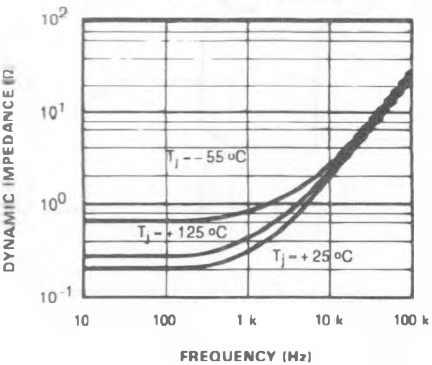
E88LM135-06

RESPONSE TIME



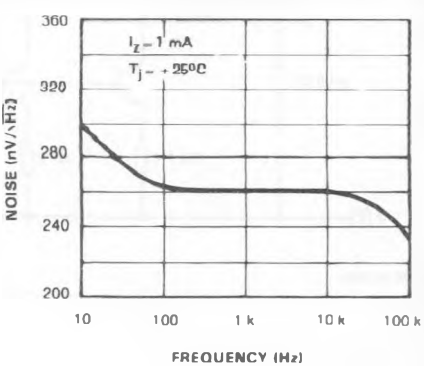
E88LM135-07

DYNAMIC IMPEDANCE



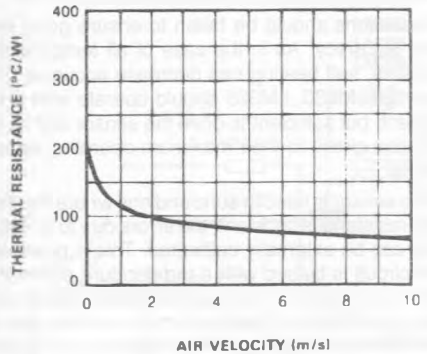
E88LM135-08

NOISE VOLTAGE



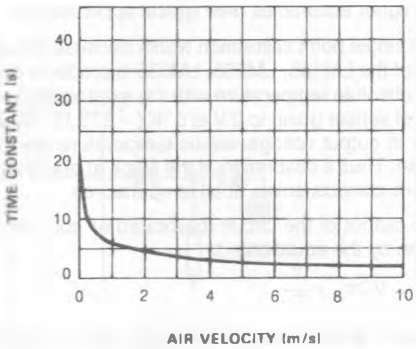
E88LM135-09

THERMAL RESISTANCE JUNCTION TO AIR



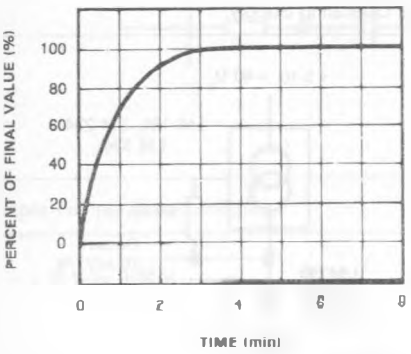
E88LM135-10

THERMAL TIME CONSTANT



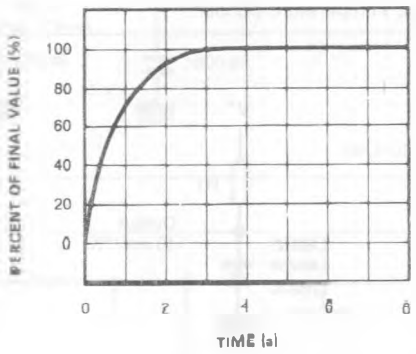
E88LM135-11

THERMAL RESPONSE IN STILL AIR



E88LM135-12

THERMAL RESPONSE IN STIRRED OIL BATH



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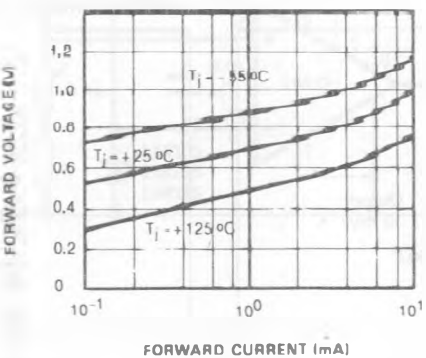
FORWARD CHARACTERICS



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 :

$$V_{OT} = V_{OT_O} \times \frac{T}{T_O}$$

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

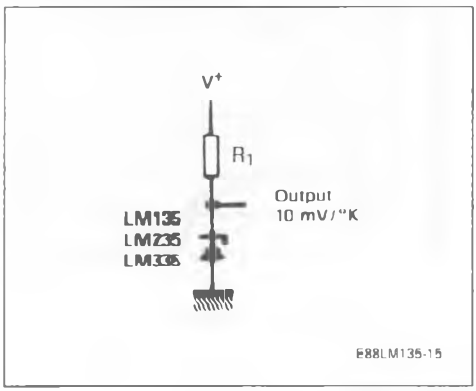
Nominally the output is calibrated at 10 mV/°K.

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.

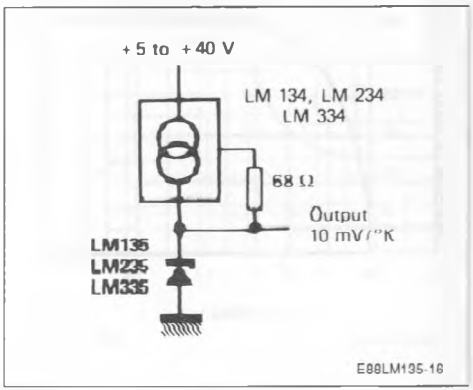
If the sensor is used in surroundings where the thermal resistane is constant, the errors due to self heating can be externally calibrated. This is possible if the circuit is biased with a temperature stable current. Heating will then be proportional to zener voltage and therefore temperature. In this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

TYPICAL APPLICATIONS

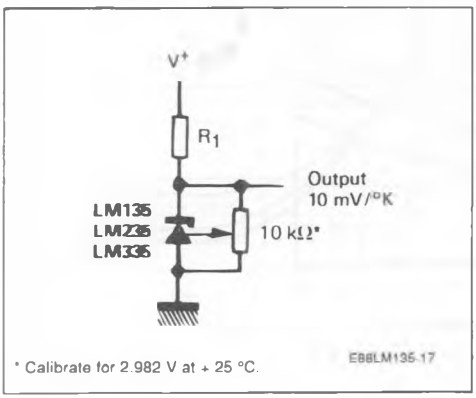
Basic Temperature Sensor.



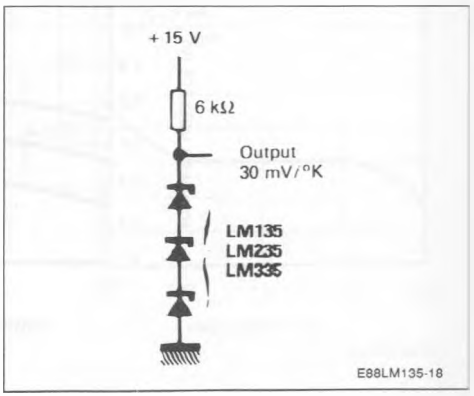
Wide Operating Supply.



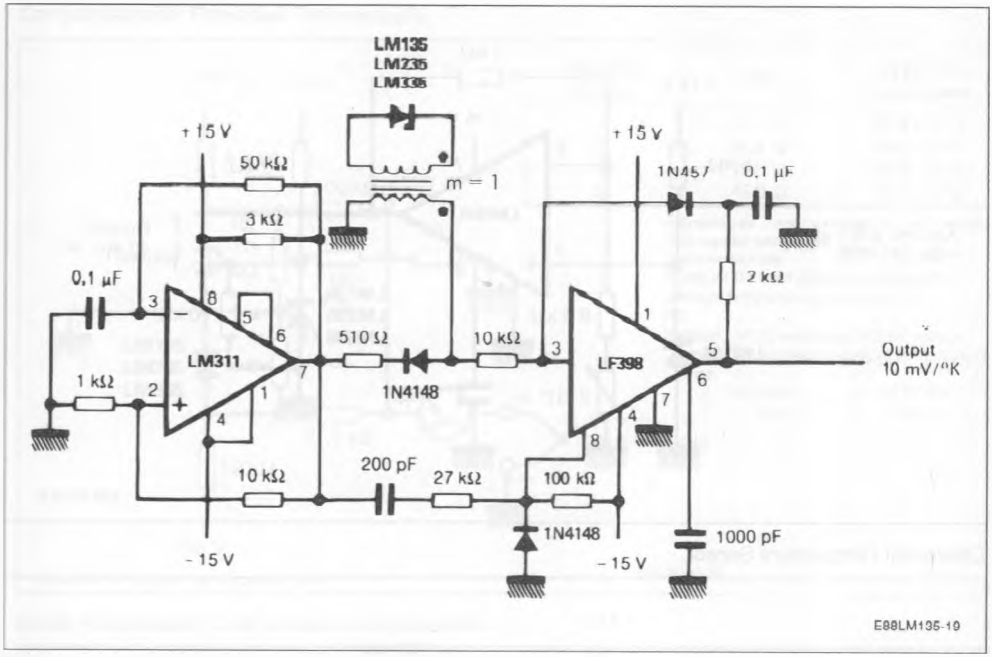
Calibrated Sensor.



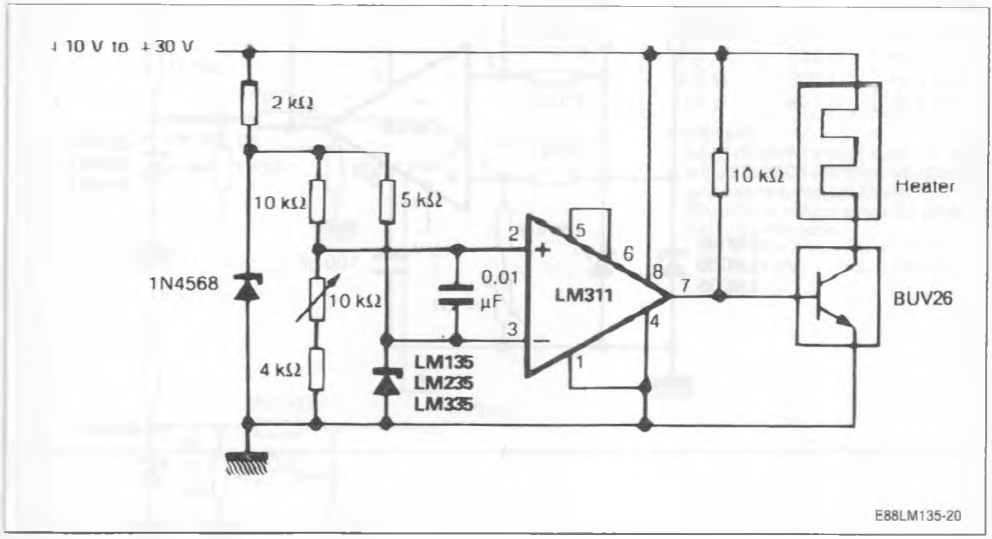
Average Temperature Sensing.



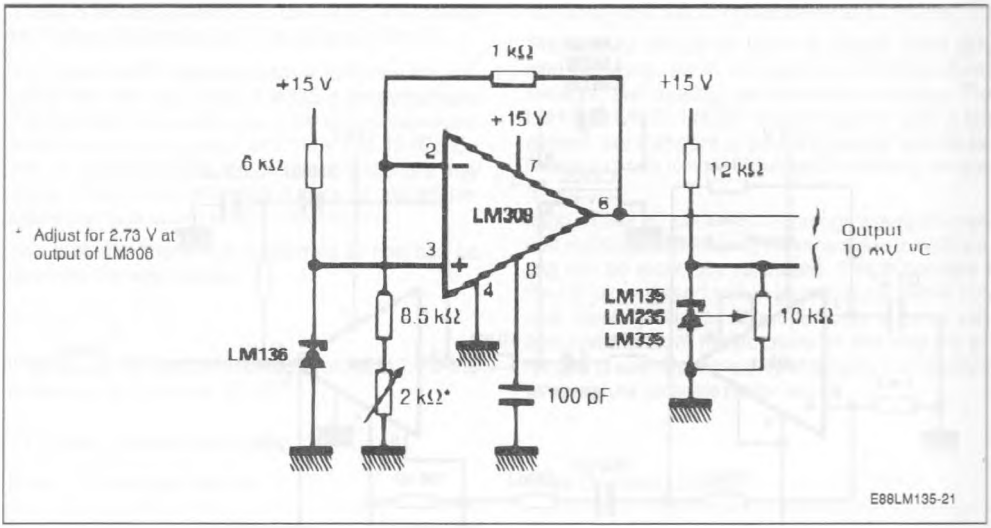
Isolated Temperature Sensor.



Simple Temperature Controller.

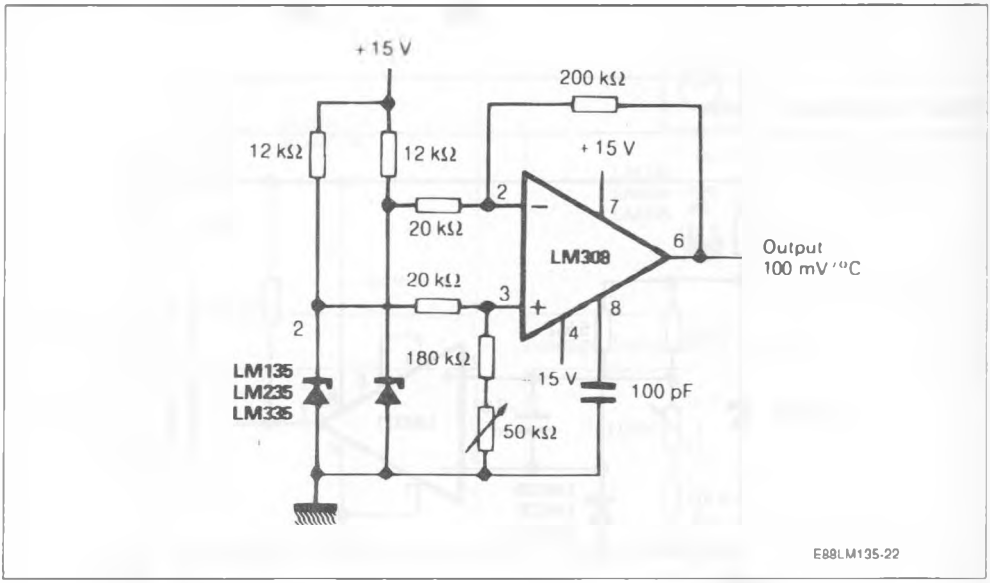


Centigrade Thermometer.



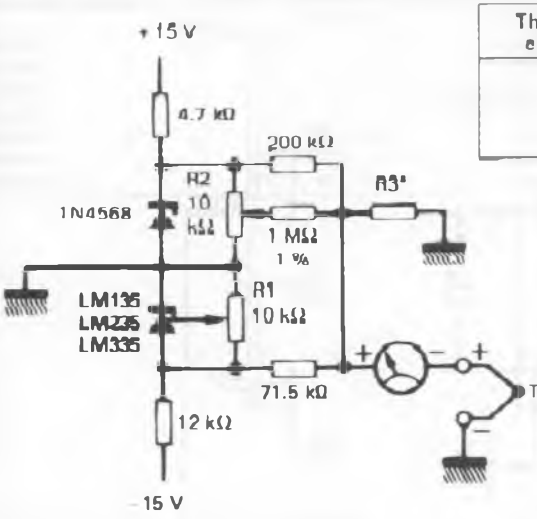
* Adjust for 2.73 V at output of LM308

Differential Temperature Sensor.



THERMOCOUPLE COLD JUNCTION COMPENSATION

Compensation for Grounded Thermocouple.



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

Adjustments : compensates for both sensor and resistor tolerances.

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

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

* Select R3 for proper thermocouple type

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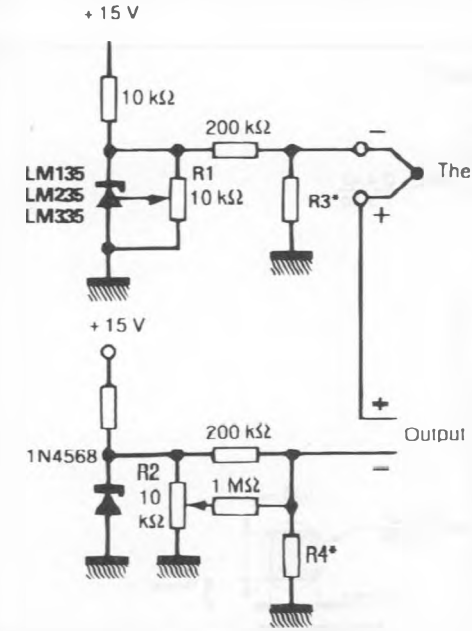
Single Power Supply Cold Junction Compensation.



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

Adjustments :

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

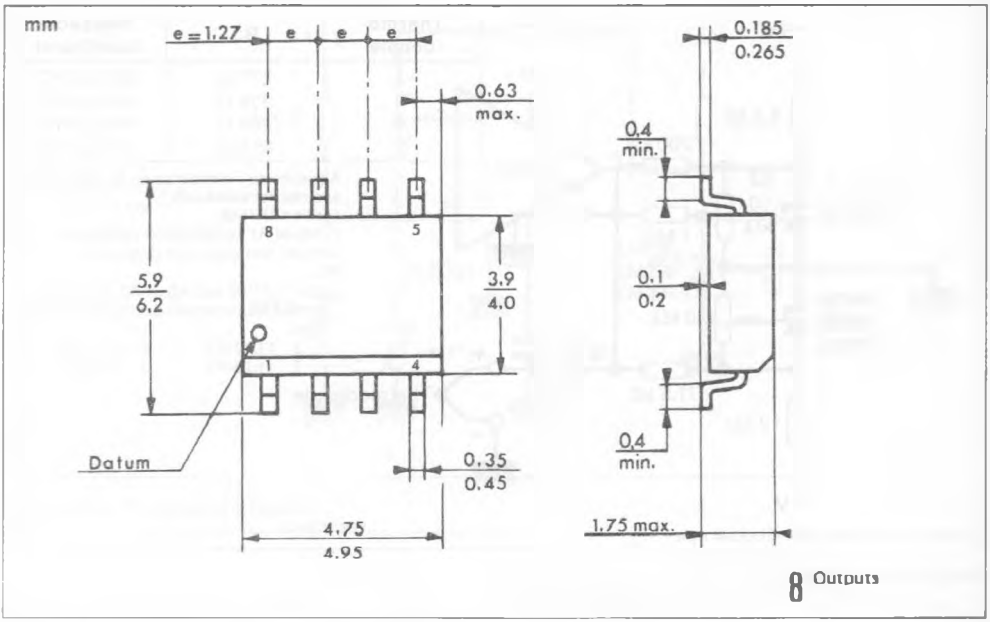
J	14.32 mV	K	11.17 mV
T	11.79 mV	S	1.768 mV

* Select R3 and R4 for proper thermocouple type

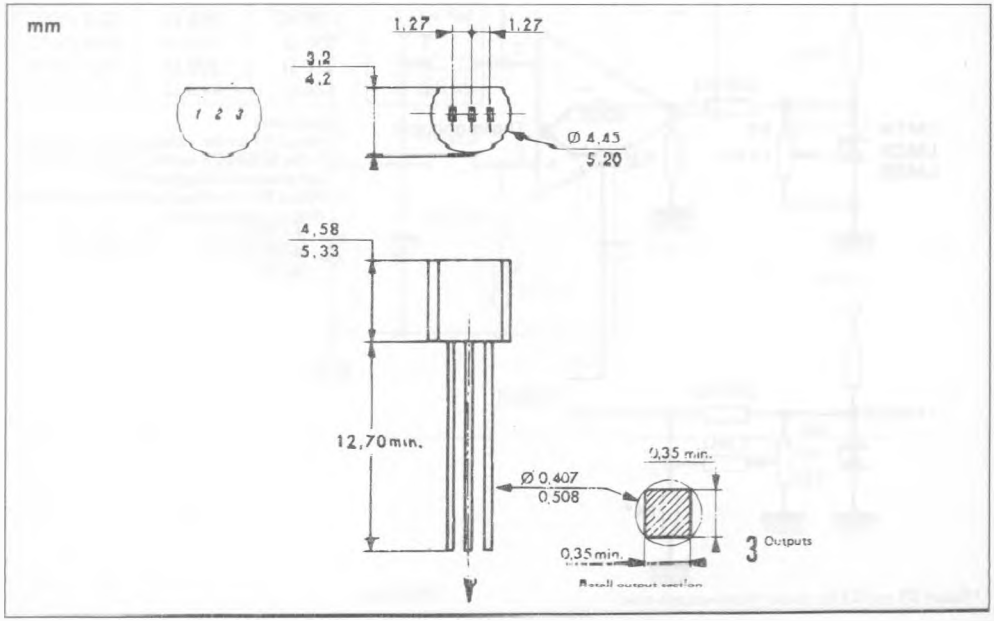
E88LM135-24

PACKAGE MECHANICAL DATA

8 PINS - PLASTIC MICROPACKAGE (SO)



3 PINS - PLASTIC PACKAGE TO92



ORDER CODES

Part number	TemperatureRange		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