MOTOROLA Semiconductors

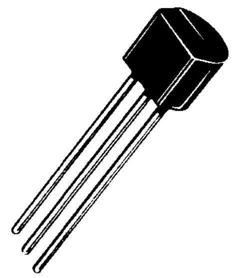
MTS102
MTS103
MTS105

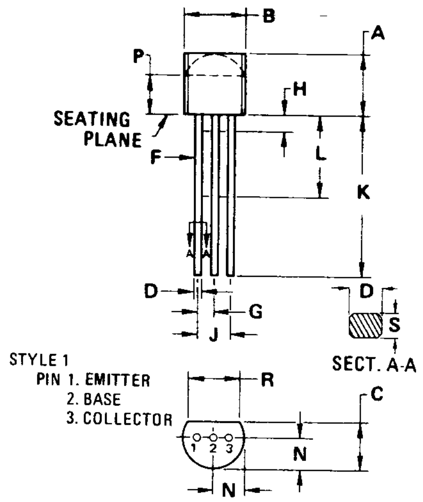
SILICON TEMPERATURE SENSORS

. . . designed for temperature sensing applications in automotive, consumer, and industrial products requiring low cost and high accuracy.

- Precise Temperature Accuracy Over Extreme Temperature
  MTS102: ±2°C from −40°C to +150°C
- Precise Temperature Coefficient
- Fast Thermal Time Constant
  3 Seconds — Liquid
  8 Seconds — Air
- Linear V_{BE} versus Temperature Curve Relationship

SILICON TEMPERATURE SENSORS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.14	1.40	0.045	0.055
H	–	2.54	–	0.100
J	2.41	2.67	0.095	0.105
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.92	0.080	0.115
P	2.92	–	0.115	–
R	3.43	–	0.135	–
S	0.36	0.41	0.014	0.016

All JEDEC dimensions and notes apply.

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous*	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

*See Note 5, page 2.

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_E = 0)	I_{CEO}	–	–	100	nAdc
Base-Emitter Voltage I_C = 0.1 mA	V_{BE}	580	600	620	mV
Base-Emitter Voltage Matching, Note 1 (I_C = 0.1 mA)	ΔV_{BE}				mV
MTS102		–	–	±3.0	
MTS103		–	–	±4.0	
MTS105		–	–	±7.0	
Temperature Accuracy, Note 2 (T1 = −40°C, T2 = +150°C)	ΔT				°C
MTS102		–	–	±2.0	
MTS103		–	–	±3.0	
MTS105		–	–	±5.0	
Temperature Coefficient, Notes 3 and 4 (V_{BE} = 600 mV, I_C = 0.1 mA)	TC	−2.26	−2.25	−2.24	mV/°C
Thermal Time Constant	τ_{TH}				s
Flowing Liquid		–	3.0	–	
Flowing Air		–	8.0	–	
Dependence of TC on V_{BE} @ 25°C (Note 4, Figure 2)	$\Delta TC/\Delta V_{BE}$	–	0.0033	–	$\frac{mV/°C}{mV}$

NOTES

1. For orders of 1000 pieces of less, devices will be matched in a single group. For larger orders, devices will be supplied in groups of 1000 minimum per group. All devices within any one group will be matched for V_{BE} to the tolerance identified in the electrical characteristics table. All groups will be labeled with the nominal V_{BE} value for that group.
2. All devices within an individual group, as described in Note 1, will track within the specified temperature accuracy. Includes variations in TC, V_{BE}, and non-linearity in the range −40 to +150°C. Non-linearity is typically less than ± 1°C in this range.
3. The TC as defined by a least-square linear regression for V_{BE} versus temperature over the range −40 to +150°C for a nominal V_{BE} of 600 mV at 25°C. For other nominal V_{BE} values the value of the TC must be adjusted for the dependence of the TC on V_{BE} (see Note 4).
4. For nominal V_{BE} at 25°C other than 600 mV, the TC must be corrected using the equation TC = −2.25 + 0.0033 (V_{BE} − 600) where V_{BE} is in mV and the TC is in mV/°C. The accuracy of this TC is typically ±0.01 mV/°C.
5. For maximum temperature accuracy, I_C should not exceed 2 mA. See Figure 1.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 — BASE-EMITTER VOLTAGE versus COLLECTOR-EMITTER CURRENT

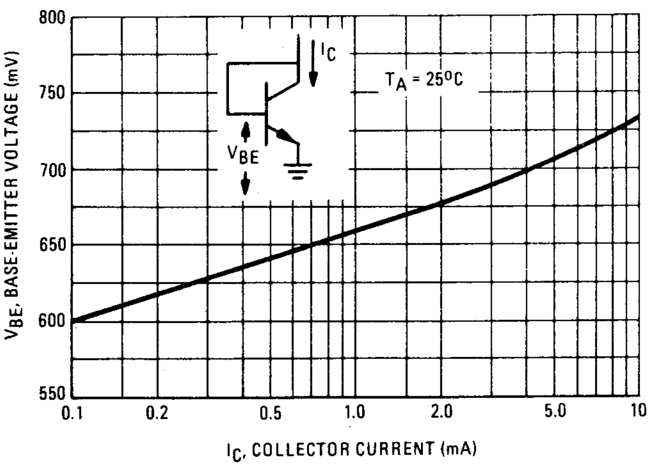


FIGURE 2 — TEMPERATURE COEFFICIENT versus BASE-EMITTER VOLTAGE

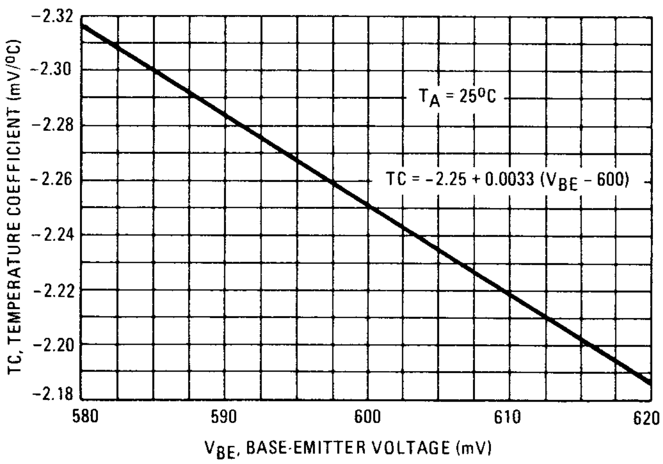
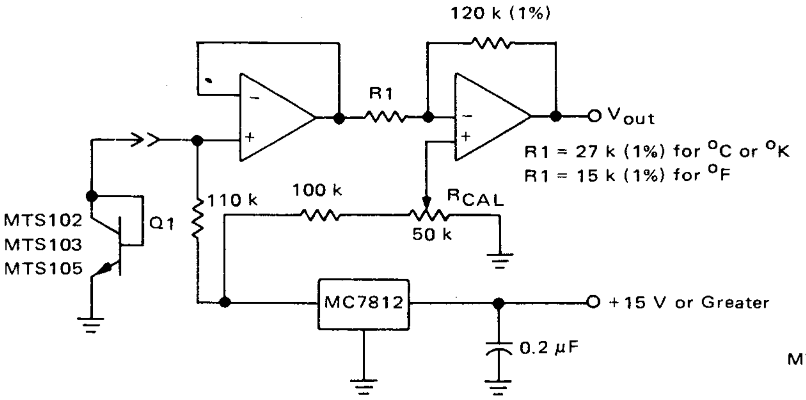
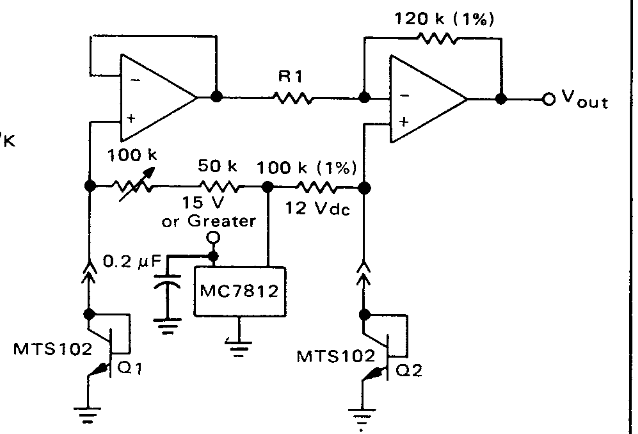


FIGURE 3 — ABSOLUTE TEMPERATURE MEASUREMENT



NOTE: With Q1 at a known temperature, adjust R_{CAL} to set output voltage to V_{out} = TEMP x 10 mV. Output of MTS102, 3, 5 is then converted to V_{out} = 10 mV/° – (°F, °C, or °K)

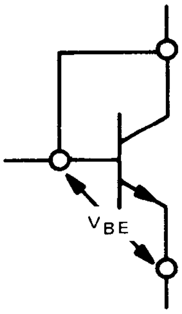
FIGURE 4 — DIFFERENTIAL TEMPERATURE MEASUREMENT



NOTE: With Q1 and Q2 at identical temperature, adjust R_{CAL} for V_{out} = 0.000 V

APPLICATIONS INFORMATION

The base and collector leads of the device should be connected together in the operating circuit (pins 2 and 3). They are not internally connected.



The following example describes how to determine the V_{BE} versus temperature relationship for a typical shipment of various V_{BE} groups.

EXAMPLE:

Given — Customer receives a shipment of MTS102 devices. The shipment consists of three groups of different nominal V_{BE} values.

Group 1: V_{BE} (nom) = 600 mV
Group 2: V_{BE} (nom) = 580 mV
Group 3: V_{BE} (nom) = 620 mV

Find — V_{BE} versus Temperature Relationship.

1. Determine value of TC:
   a. If V_{BE} (nom) = 600 mV, TC = –2.25 mV/°C from the Electrical Characteristics table.
   b. If V_{BE} (nom) is less than or greater than 600 mV determine TC from the relationship described in Note 4.

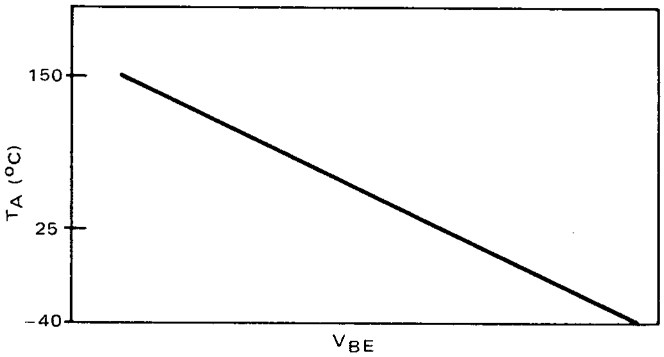
   (1) $TC = -2.25 + 0.0033\,(V_{BE} - 600)$ or see Figure 2.

2. Determine the V_{BE} value at the extremes, –40°C and +150°C:

   (2) $V_{BE(T_A)} = V_{BE(25^\circ C)} + (TC)(T_A - 25^\circ C)$

   where $V_{BE(T_A)}$ = value of V_{BE} at desired temperature.

3. Plot the V_{BE} versus T_A curve using two V_{BE} values: $V_{BE(-40^\circ C)}$, $V_{BE(25^\circ C)}$, or $V_{BE(+150^\circ C)}$.



4. Given any measured V_{BE}, the value of T_A (to the accuracy value specified: MTS102 – ±2°C, MTS103 – ±3°C, MTS105 – ±5°C) can be read from the above curve, or calculated from equation 2.

GROUP 1: V_{BE} (nom) = 600 mV = $V_{BE(25^oC)}$

From the Electrical Characteristics table:

1. TC = −2.25 mV/°C for V_{BE} = 600 mV
2. $V_{BE(150^oC)} = V_{BE(@\ 25^oC)} + (TC)(150 - 25)$
   $= 600 + (-2.25)(125)$
   $= 600 - 281.25$
   $= 318.75$ mV
3. The calibration curve for any device randomly selected from this group with V_{BE} (nom) = 600 mV is shown below.

GROUP 2: V_{BE} (nom) = 580 mV = $V_{BE(25^oC)}$

1. TC $= -2.25 + 0.0033(V_{BE} - 600)$
   $= -2.25 + 0.0033(580 - 600)$
   $= -2.25 - 0.066$
   $= -2.316$
2. $V_{BE(150^oC)} = V_{BE(25^oC)} + TC(T_A - 25^oC)$
   $= 580 + (-2.316)(150 - 25)$
   $= 580 + (-2.316)(125)$
   $= 290.5$ mV
3. The calibration curve for any device randomly selected from this group with V_{BE} (nom) = 580 mV is shown below.

GROUP 3: V_{BE} (nom) = 620 mV = $V_{BE(25^oC)}$

1. TC $= -2.25 + 0.0033(V_{BE} - 600)$
   $= -2.25 + 0.0033(620 - 600)$
   $= -2.184$
2. $V_{BE(150^oC)} = V_{BE(25^oC)} + (TC)(T_A - 25^oC)$
   $= 620 + (-2.184)(150 - 25)$
   $= 347$ mV
3. The calibration curve for any device randomly selected from this group with V_{BE} (nom) = 620 mV is shown below.

FIGURE 5 — AMBIENT TEMPERATURE versus BASE-EMITTER VOLTAGE