

## General Purpose Transistor

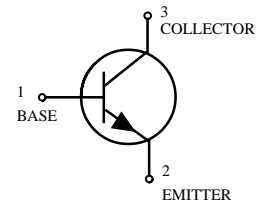
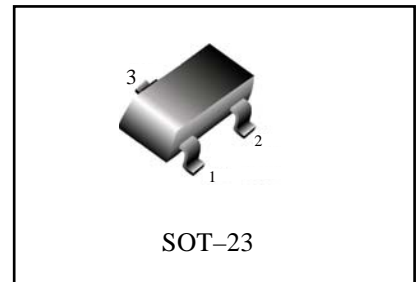
- We declare that the material of product compliance with RoHS requirements.

### ORDERING INFORMATION

| Device  | Marking | Shipping         |
|---------|---------|------------------|
| 2N3904S | 1AM     | 3000/Tape & Reel |

### MAXIMUM RATINGS

| Rating                         | Symbol    | Value | Unit |
|--------------------------------|-----------|-------|------|
| Collector-Emitter Voltage      | $V_{CEO}$ | 40    | Vdc  |
| Collector-Base Voltage         | $V_{CBO}$ | 60    | Vdc  |
| Emitter-Base Voltage           | $V_{EBO}$ | 6.0   | Vdc  |
| Collector Current — Continuous | $I_C$     | 200   | mAdc |



### THERMAL CHARACTERISTICS

| Characteristic   | Symbol          | Max         | Unit  |
|--|-----------------|-------------|-------|
| Total Device Dissipation FR-5 Board, (1)<br>$T_A = 25\text{ C}$        | $P_D$           | 225         | mW    |
| Derate above 25 C  |                 | 1.8         | mW/ C |
| Thermal Resistance, Junction to Ambient                                | $R_{\theta JA}$ | 556         | C/W   |
| Total Device Dissipation<br>Alumina Substrate, (2) $T_A = 25\text{ C}$ | $P_D$           | 300         | mW    |
| Derate above 25 C  |                 | 2.4         | mW/ C |
| Thermal Resistance, Junction to Ambient                                | $R_{\theta JA}$ | 417         | C/W   |
| Junction and Storage Temperature                                       | $T_J, T_{stg}$  | -55 to +150 | C     |

### ELECTRICAL CHARACTERISTICS ( $T_A = 25\text{ C}$ unless otherwise noted.)

| Characteristic  | Symbol        | Min | Max | Unit |
|---|---------------|-----|-----|------|
| <b>OFF CHARACTERISTICS</b>  |               |     |     |      |
| Collector-Emitter Breakdown Voltage(3)<br>( $I_C = 1.0\text{ mAdc}$ )             | $V_{(BR)CEO}$ | 40  | -   | Vdc  |
| Collector-Base Breakdown Voltage<br>( $I_C = 10\text{ }\mu\text{Adc}$ )           | $V_{(BR)CBO}$ | 60  | -   | Vdc  |
| Emitter-Base Breakdown Voltage<br>( $I_E = 10\text{ }\mu\text{Adc}$ )             | $V_{(BR)EBO}$ | 6.0 | -   | Vdc  |
| Base Cutoff Current<br>( $V_{CE} = 30\text{ Vdc}, V_{EB} = 3.0\text{ Vdc},$ )     | $I_{BL}$      | -   | 50  | nAdc |
| Collector Cutoff Current<br>( $V_{CE} = 30\text{ Vdc}, V_{BE} = 3.0\text{ Vdc}$ ) | $I_{CEX}$     | -   | 50  | nAdc |

1. FR-5 = 1.0 x 0.75 x 0.062 in.
2. Alumina = 0.4 x 0.3 x 0.024 in. 99.5% alumina.
3. Pulse Test: Pulse Width  $\leq 300\text{ }\mu\text{s}$ , Duty Cycle  $\leq 2.0\%$ .

## ELECTRICAL CHARACTERISTICS ( $T_A$ 25°C unless otherwise noted)

| Characteristic   | Symbol        | Min                         | Max                     | Unit             |
|--|---------------|-----------------------------|-------------------------|------------------|
| <b>ON CHARACTERISTICS (3)</b>  |               |                             |                         |                  |
| DC Current Gain<br>( $I_C = 0.1$ mA dc, $V_{CE} = 1.0$ V dc)<br>( $I_C = 1.0$ mA dc, $V_{CE} = 1.0$ V dc)<br>( $I_C = 10$ mA dc, $V_{CE} = 1.0$ V dc)<br>( $I_C = 50$ mA dc, $V_{CE} = 1.0$ V dc)<br>( $I_C = 100$ mA dc, $V_{CE} = 1.0$ V dc) | $h_{FE}$      | 40<br>70<br>100<br>60<br>30 | –<br>–<br>300<br>–<br>– | –                |
| Collector–Emitter Saturation Voltage<br>( $I_C = 10$ mA dc, $I_B = 1.0$ mA dc)<br>( $I_C = 50$ mA dc, $I_B = 5.0$ mA dc)   | $V_{CE(sat)}$ | –<br>–                      | 0.2<br>0.3              | V dc             |
| Base–Emitter Saturation Voltage<br>( $I_C = 10$ mA dc, $I_B = 1.0$ mA dc)<br>( $I_C = 50$ mA dc, $I_B = 5.0$ mA dc)  | $V_{BE(sat)}$ | 0.65<br>–                   | 0.85<br>0.95            | V dc             |
| <b>SMALL–SIGNAL CHARACTERISTICS</b>  |               |                             |                         |                  |
| Current–Gain – Bandwidth Product<br>( $I_C = 10$ mA dc, $V_{CE} = 20$ V dc, $f = 100$ MHz)   | $f_T$         | 300                         | –                       | MHz              |
| Output Capacitance<br>( $V_{CB} = 5.0$ V dc, $I_E = 0$ , $f = 1.0$ MHz)  | $C_{obo}$     | –                           | 4.0                     | pF               |
| Input Capacitance<br>( $V_{EB} = 0.5$ V dc, $I_C = 0$ , $f = 1.0$ MHz)   | $C_{ibo}$     | –                           | 8.0                     | pF               |
| Input Impedance<br>( $V_{CE} = 10$ V dc, $I_C = 1.0$ mA dc, $f = 1.0$ kHz)   | $h_{ie}$      | 1.0                         | 10                      | k $\Omega$       |
| Voltage Feedback Ratio<br>( $V_{CE} = 10$ V dc, $I_C = 1.0$ mA dc, $f = 1.0$ kHz)  | $h_{re}$      | 0.5                         | 8.0                     | $\times 10^{-4}$ |
| Small–Signal Current Gain<br>( $V_{CE} = 10$ V dc, $I_C = 1.0$ mA dc, $f = 1.0$ kHz)   | $h_{fe}$      | 100                         | 400                     | –                |
| Output Admittance<br>( $V_{CE} = 10$ V dc, $I_C = 1.0$ mA dc, $f = 1.0$ kHz)   | $h_{oe}$      | 1.0                         | 40                      | $\mu$ mhos       |
| Noise Figure<br>( $V_{CE} = 5.0$ V dc, $I_C = 100$ $\mu$ A dc, $R_S = 1.0$ k $\Omega$ , $f = 1.0$ kHz)   | NF            | –                           | 5.0                     | dB               |

## SWITCHING CHARACTERISTICS

|              |  |       |   |     |    |
|--------------|--|-------|---|-----|----|
| Delay Time   | ( $V_{CC} = 3.0$ V dc, $V_{BE} = -0.5$ V dc) | $t_d$ | – | 35  | ns |
| Rise Time    | $I_C = 10$ mA dc, $I_{B1} = 1.0$ mA dc)      | $t_r$ | – | 35  | ns |
| Storage Time | ( $V_{CC} = 3.0$ V dc, $I_C = 10$ mA dc)     | $t_s$ | – | 200 | ns |
| Fall Time    | $I_{B1} = I_{B2} = 1.0$ mA dc)               | $t_f$ | – | 50  | ns |

3. Pulse Test: Pulse Width  $\leq 300$   $\mu$ s; Duty Cycle  $\leq 2.0\%$ .

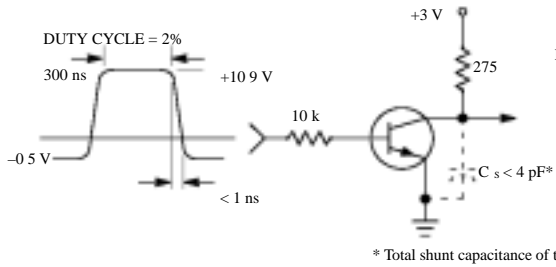


Figure 1. Delay and Rise Time  
Equivalent Test Circuit

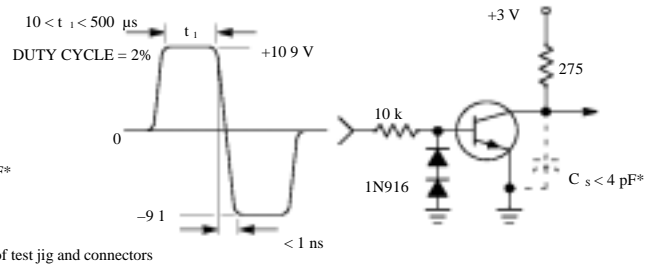


Figure 2. Storage and Fall Time  
Equivalent Test Circuit

## TYPICAL TRANSIENT CHARACTERISTICS

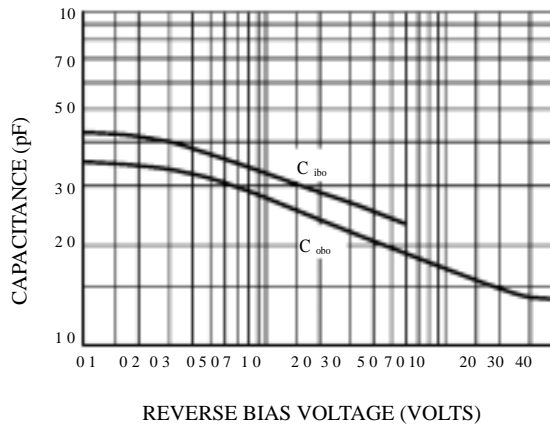


Figure 3. Capacitance

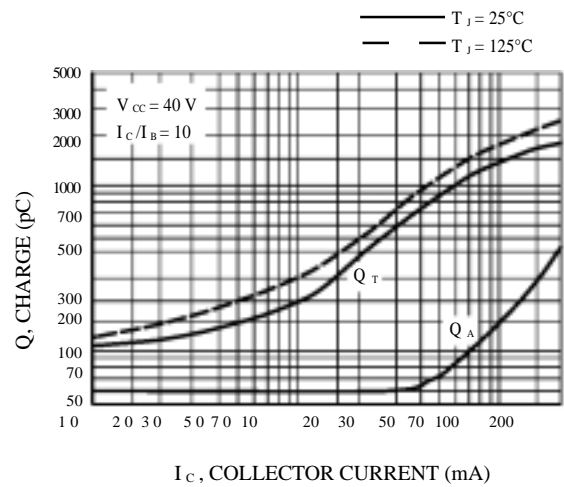


Figure 4. Charge Data

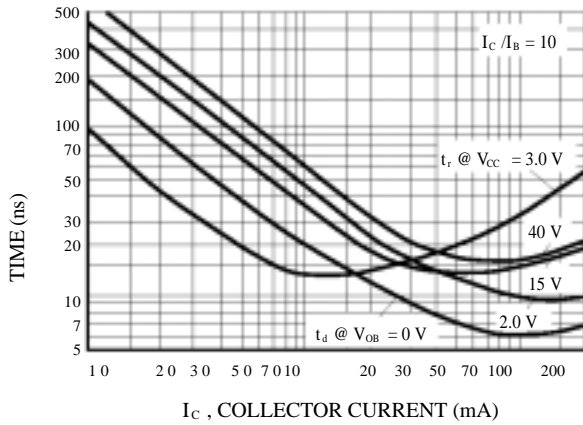


Figure 5. Turn-On Time

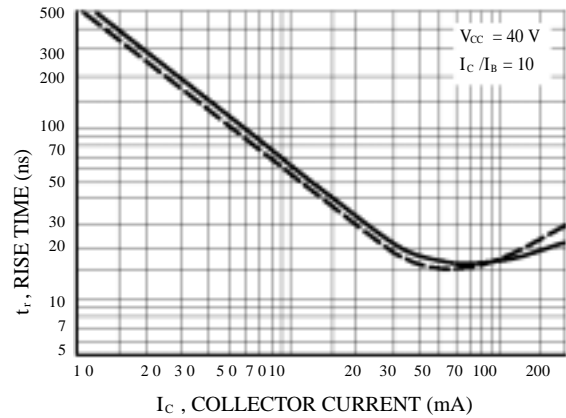


Figure 6. Rise Time

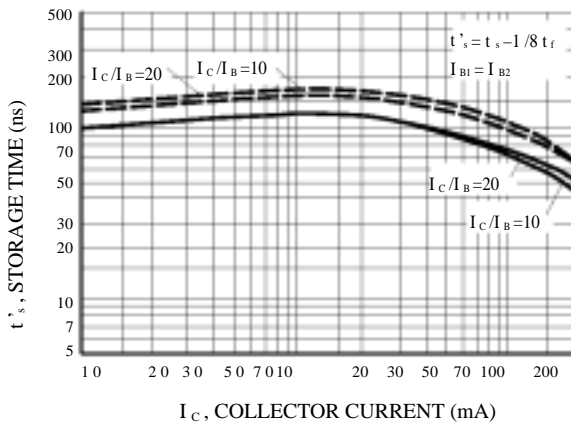


Figure 7. Storage Time

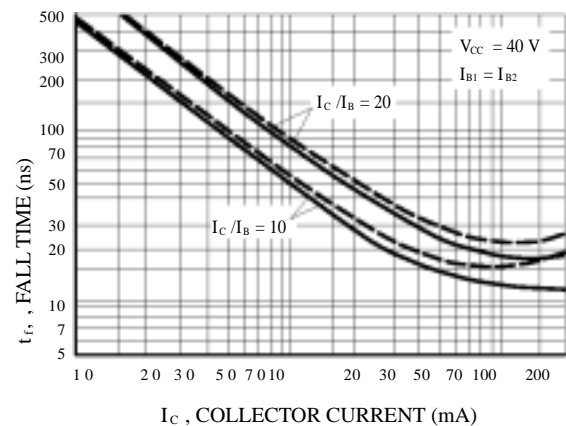


Figure 8. Fall Time

## TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS

### NOISE FIGURE VARIATIONS

( $V_{CE} = 5.0$  Vdc,  $T_A = 25^\circ\text{C}$ , Bandwidth = 1.0 Hz)

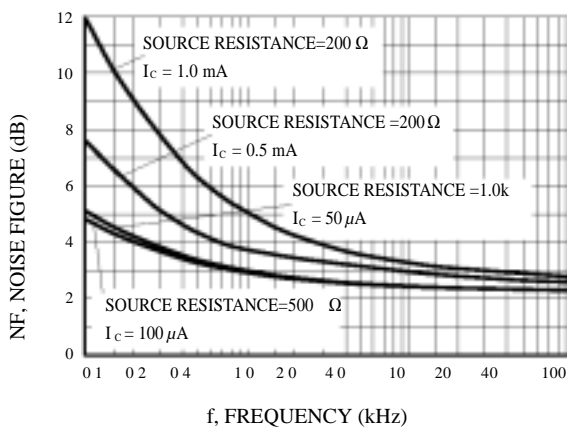


Figure 9.

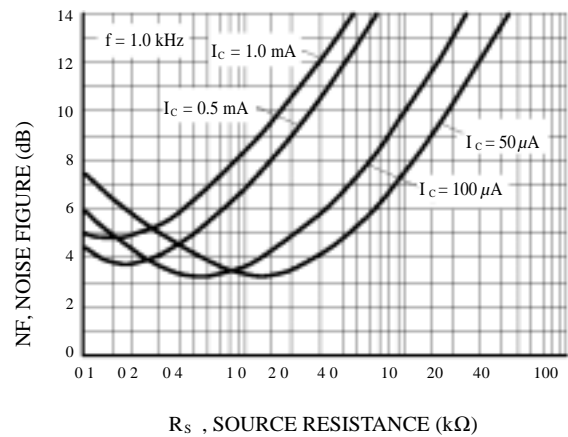


Figure 10.

## h PARAMETERS

( $V_{CE} = 10 \text{ Vdc}$ ,  $f = 1.0 \text{ kHz}$ ,  $T_A = 25^\circ\text{C}$ )

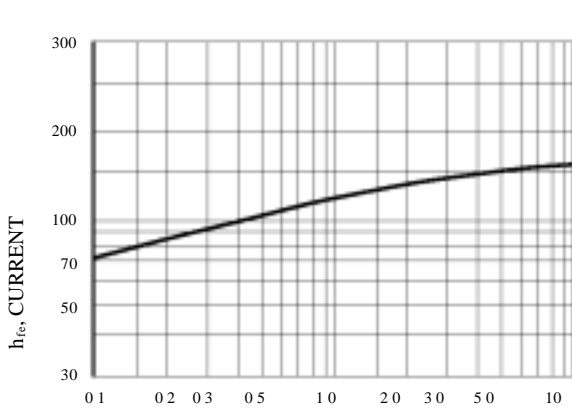


Figure 11. Current Gain

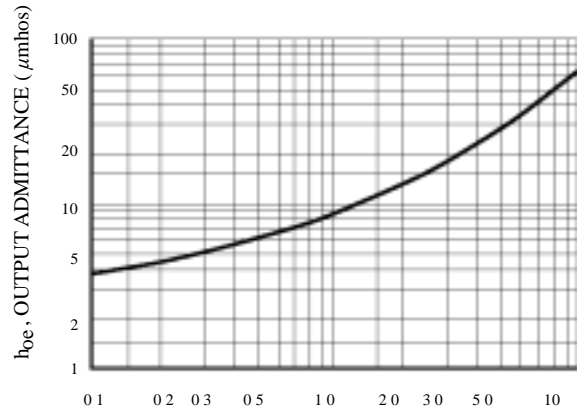


Figure 12. Output Admittance

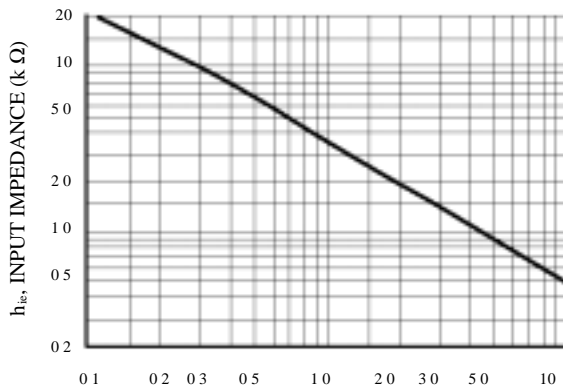


Figure 13. Input Impedance

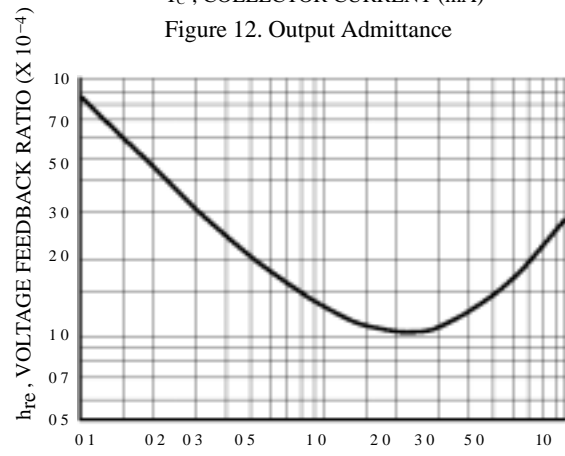


Figure 14. Voltage Feedback Ratio

## TYPICAL STATIC CHARACTERISTICS

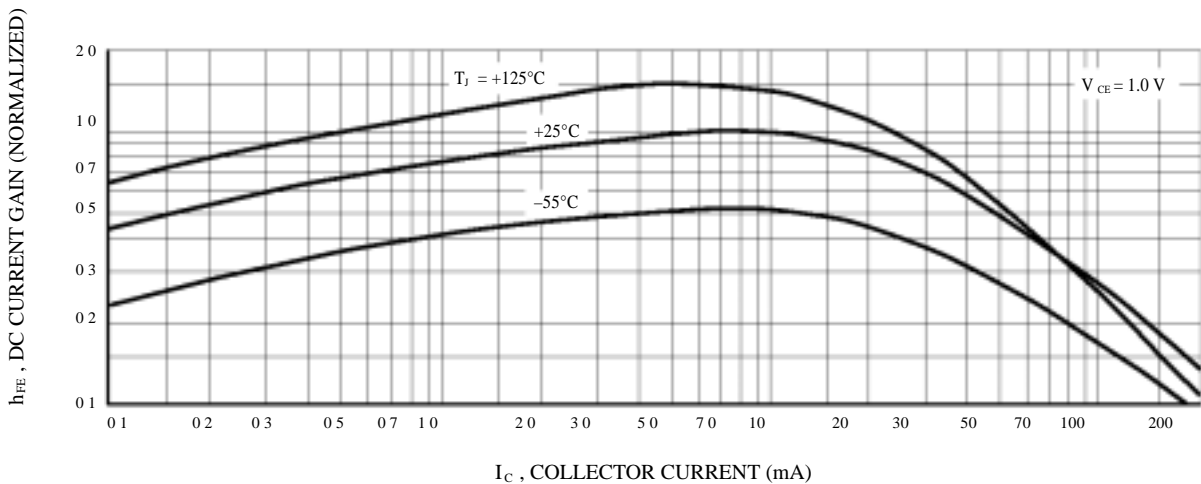


Figure 15. DC Current Gain

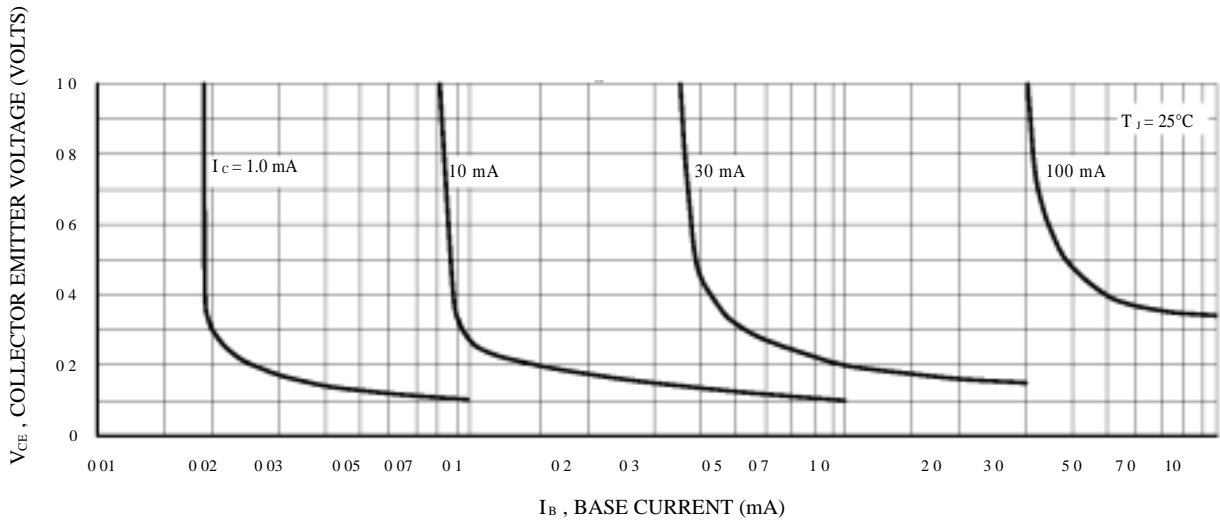
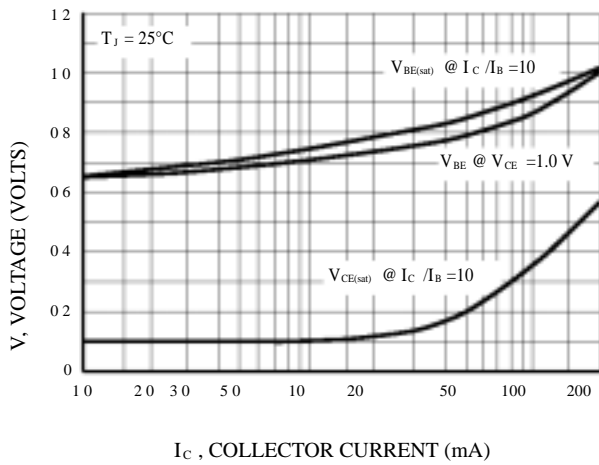
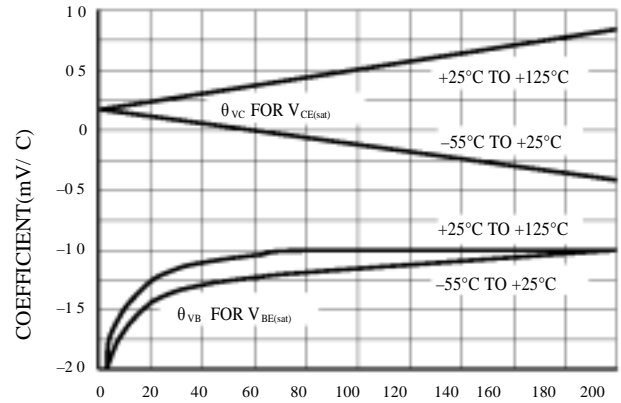


Figure 16. Collector Saturation Region



$I_C$ , COLLECTOR CURRENT (mA)  
Figure 17. "ON" Voltages

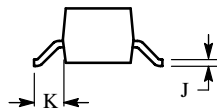
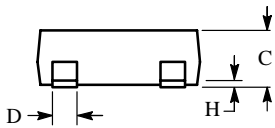
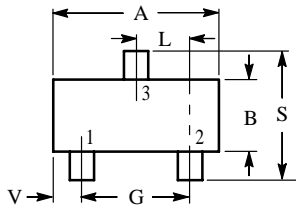


$I_C$ , COLLECTOR CURRENT (mA)  
Figure 18. Temperature Coefficients

## SOT-23

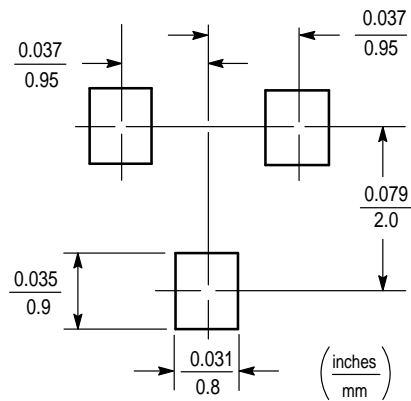
### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M,1982
2. CONTROLLING DIMENSION: INCH.

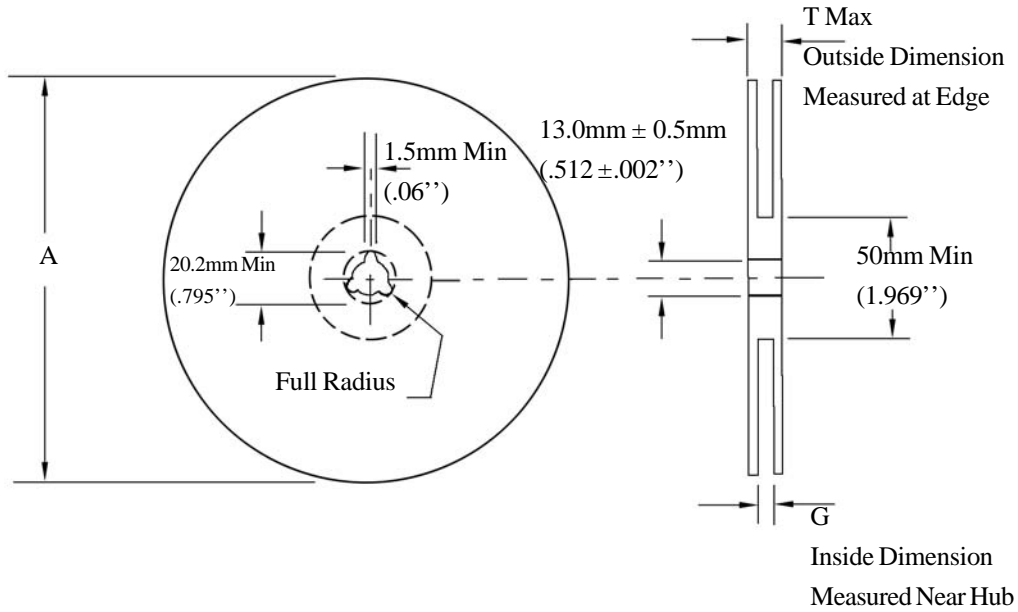


| DIM | INCHES |        | MILLIMETERS |       |
|-----|--------|--------|-------------|-------|
|     | MIN    | MAX    | MIN         | MAX   |
| A   | 0.1102 | 0.1197 | 2.80        | 3.04  |
| B   | 0.0472 | 0.0551 | 1.20        | 1.40  |
| C   | 0.0350 | 0.0440 | 0.89        | 1.11  |
| D   | 0.0150 | 0.0200 | 0.37        | 0.50  |
| G   | 0.0701 | 0.0807 | 1.78        | 2.04  |
| H   | 0.0005 | 0.0040 | 0.013       | 0.100 |
| J   | 0.0034 | 0.0070 | 0.085       | 0.177 |
| K   | 0.0140 | 0.0285 | 0.35        | 0.69  |
| L   | 0.0350 | 0.0401 | 0.89        | 1.02  |
| S   | 0.0830 | 0.1039 | 2.10        | 2.64  |
| V   | 0.0177 | 0.0236 | 0.45        | 0.60  |

PIN 1 BASE  
 2 EMITTER  
 3 COLLECTOR



## EMBOSSED TAPE AND REEL DATA FOR DISCRETES



| Size | A Max               | G  | T Max             |
|------|---------------------|--|-------------------|
| 8 mm | 330mm<br>(12.992'') | 8.4mm+1.5mm, -0.0<br>(.33''+.059'', -0.00) | 14.4mm<br>(.56'') |

### Reel Dimensions

Metric Dimensions Govern — English are in parentheses for reference only

### Storage Conditions

Temperature: 5 to 40 Deg.C (20 to 30 Deg. C is preferred)

Humidity: 30 to 80 RH (40 to 60 is preferred )

Recommended Period: One year after manufacturing

(This recommended period is for the soldering condition only. The characteristics and reliabilities of the products are not restricted to this limitation)