# General Purpose Transistors

## NPN Silicon

3 COLLECTOR

1 BASE

2 EMITTER

**BCX70GLT1**
**BCX70JLT1**
**BCX70KLT1**



**CASE 318–08, STYLE 6**
**SOT–23 (TO–236AB)**
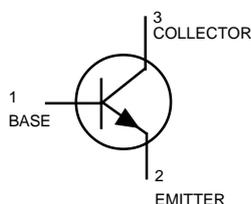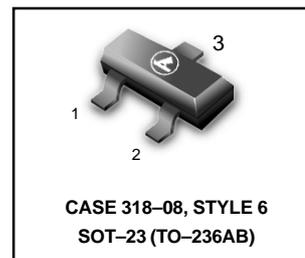
### MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Collector–Emitter Voltage | $V_{CEO}$ | 45 | Vdc |
| Collector–Base Voltage | $V_{CBO}$ | 45 | Vdc |
| Emitter–Base Voltage | $V_{EBO}$ | 5.0 | Vdc |
| Collector Current — Continuous | $I_C$ | 200 | mAdc |

### THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max | Unit |
|---|---|---|---|
| Total Device Dissipation FR– 5 Board, (1) $T_A = 25°C$ | $P_D$ | 225 | mW |
| Derate above 25°C | | 1.8 | mW/°C |
| Thermal Resistance, Junction to Ambient | $R_{\theta JA}$ | 556 | °C/W |
| Total Device Dissipation Alumina Substrate, (2) $T_A = 25°C$ | $P_D$ | 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 |

### DEVICE MARKING

BCX70GLT1 = AG ;  BCX70JLT1 = AJ ;  BCX70KLT1 = AK ;

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

| Characteristic | Symbol | Min | Max | Unit |
|---|---|---|---|---|

**OFF CHARACTERISTICS**

| Characteristic | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Collector–Emitter Breakdown Voltage ($I_C = 2.0$mAdc, $I_E = 0$ ) | $V_{(BR)CEO}$ | 45 | — | Vdc |
| Emitter–Base Breakdown Voltage ($I_E = 1.0$ μAdc, $I_C = 0$) | $V_{(BR)EBO}$ | 5.0 | — | Vdc |
| Collector Cutoff Current ($V_{CE} = 32$ Vdc, ) | $I_{CES}$ | — | 20 | nAdc |
| ($V_{CE} = 32$ Vdc, $T_A = 150°C$ ) | | — | 20 | μAdc |
| Emitter Cutoff Current ($V_{EB} = 4.0$ Vdc, $I_C = 0$ ) | $I_{EBO}$ | — | 20 | 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.

## BCX70GLT1   BCX70JLT1   BCX70KLT1

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

| Characteristic | | Symbol | Min | Max | Unit |
|---|---|---|---|---|---|
| **ON CHARACTERISTICS** | | | | | |
| DC Current Gain | | $h_{FE}$ | | | — |
| ( $I_C$= 10 µAdc, $V_{CE}$ = 5.0 Vdc ) | BCX70G | | — | — | |
| | BCX70J | | 40 | — | |
| | BCX70K | | 100 | — | |
| ( $I_C$= 2.0 mAdc, $V_{CE}$ = 5.0 Vdc ) | BCX70G | | 120 | 220 | |
| | BCX70J | | 250 | 460 | |
| | BCX70K | | 380 | 630 | |
| ( $I_C$= 50 mAdc, $V_{CE}$ = 1.0 Vdc ) | BCX70G | | 60 | — | |
| | BCX70J | | 90 | — | |
| | BCX70K | | 100 | — | |
| Collector–Emitter Saturation Voltage | | $V_{CE(sat)}$ | | | Vdc |
| ( $I_C$ = 50 mAdc, $I_B$ = 1.25 mAdc ) | | | — | 0.55 | |
| ( $I_C$ = 10 mAdc, $I_B$ = 0.25mAdc ) | | | — | 0.35 | |
| Base–Emitter Saturation Voltage | | $V_{BE(sat)}$ | | | Vdc |
| ( $I_C$ = 50 mAdc, $I_B$ = 1.25 mAdc ) | | | 0.7 | 1.05 | |
| ( $I_C$ = 50 mAdc, $I_B$ = 0.25mAdc ) | | | 0.6 | 0.85 | |
| Base–Emitter On Voltage | | $V_{BE(on)}$ | 0.55 | 0.75 | Vdc |
| ( $I_C$ = 2.0 mAdc, $V_{CE}$ = 0.5Vdc ) | | | | | |

**SMALL–SIGNAL CHARACTERISTICS**

| Characteristic | | Symbol | Min | Max | Unit |
|---|---|---|---|---|---|
| Current–Gain — Bandwidth Product | | $f_T$ | 125 | — | MHz |
| ($I_C$ = 10mAdc, $V_{CE}$ = 5.0 Vdc, f = 100 MHz) | | | | | |
| Output Capacitance | | $C_{obo}$ | — | 4.5 | pF |
| ($V_{CB}$ = 10 Vdc, $I_C$ = 0, f = 1.0 MHz) | | | | | |
| Small–Signal Current Gain | | $h_{FE}$ | | | — |
| ($I_C$ = 2.0 mAdc, $V_{CE}$ = 5.0 Vdc, f = 1.0 kHz) | BCX70G | | 125 | 250 | |
| | BCX70J | | 250 | 500 | |
| | BCX70K | | 350 | 700 | |
| Noise Figure | | NF | — | 6.0 | dB |
| ($V_{CE}$ = 5.0 Vdc, $I_C$ = 0.2 mAdc, $R_S$ = 2.0 kΩ, f = 1.0 kHz, BW = 200 Hz) | | | | | |

**SWITCHING CHARACTERISTICS**

| Characteristic | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Turn–On Time | $t_{on}$ | — | 150 | ns |
| ( $I_C$= 10 mAdc; $I_{B1}$= 1.0 mAdc ) | | | | |
| Turn–Off Time | $t_{off}$ | — | 800 | ns |
| ( $I_{B2}$= 1.0 mAdc; $V_{BB}$ =3.6Vdc; $R_1$ = $R_2$ = 5.0 kΩ ; $R_L$ =990Ω ) | | | | |

### EQUIVALENT SWITCHING TIME TEST CIRCUITS



*Total shunt capacitance of test jig and connectors
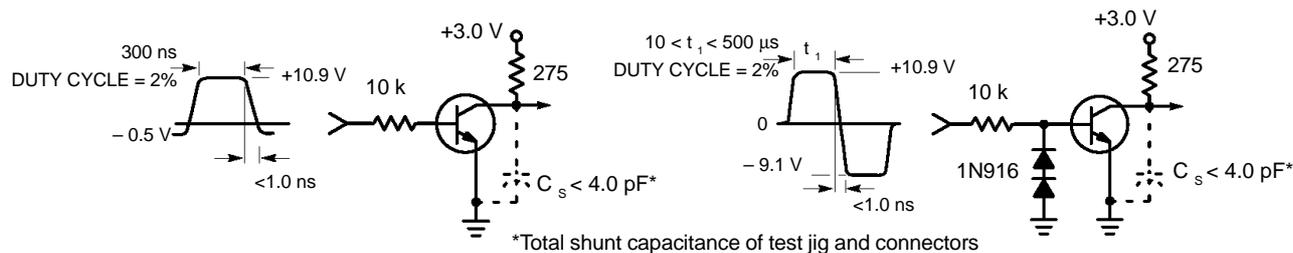
**Figure 1. Turn–On Time**

**Figure 2. Turn–Off Time**

## BCX70GLT1   BCX70JLT1   BCX70KLT1

### TYPICAL NOISE CHARACTERISTICS

$(V_{CE} = 5.0 \text{ Vdc}, T_A = 25°C)$
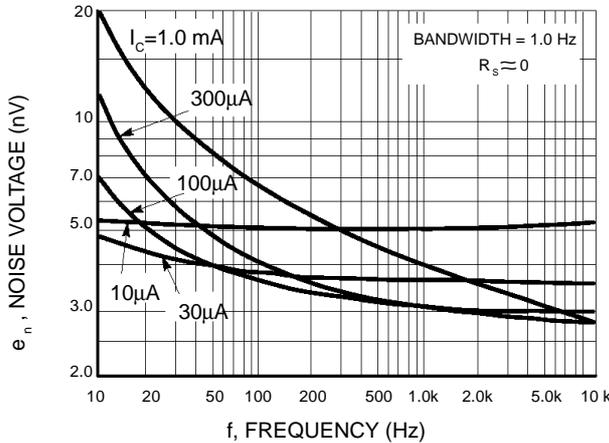


Figure 3. Noise Voltage
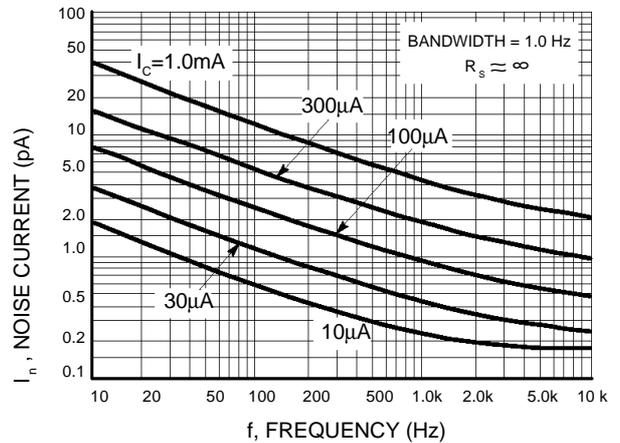


Figure 4. Noise Current

### NOISE FIGURE CONTOURS

$(V_{CE} = 5.0 \text{ Vdc}, T_A = 25°C)$
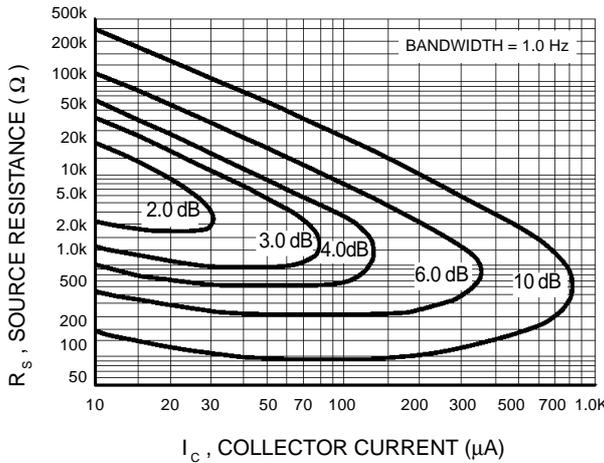


Figure 5. Narrow Band, 100 Hz
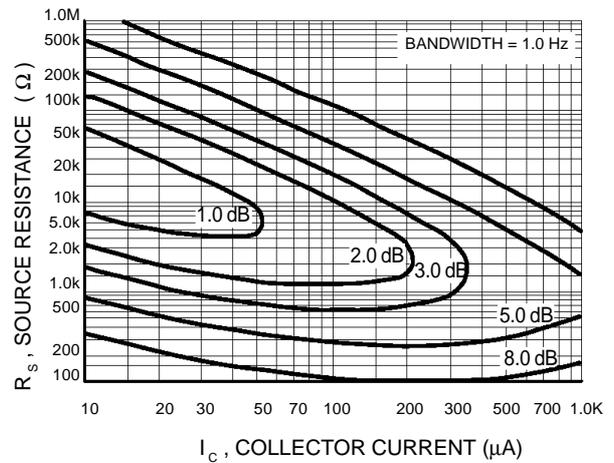


Figure 6. Narrow Band, 1.0 kHz
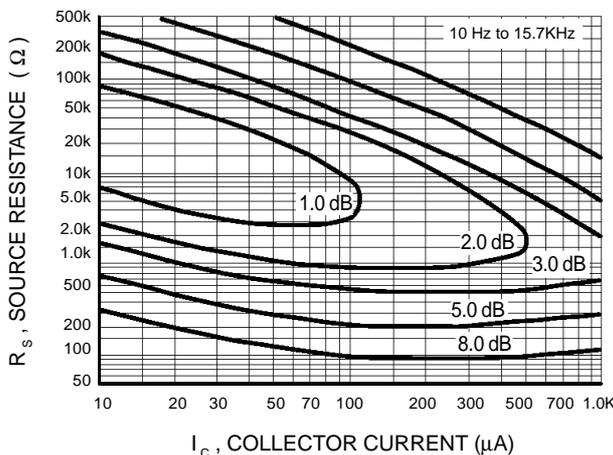


Figure 7. Wideband

Noise Figure is Defined as:

$$NF = 20 \log_{10} \left( \frac{e_n^2 + 4KTR_S + I_n^2 R_S^2}{4KTR_S} \right)^{1/2}$$

$e_n$ = Noise Voltage of the Transistor referred to the input. (Figure 3)
$I_n$ = Noise Current of the Transistor referred to the input. (Figure 4)
K  = Boltzman's Constant ($1.38 \times 10^{-23}$ j/°K)
T  = Temperature of the Source Resistance (°K)
$R_s$ = Source Resistance ($\Omega$)

**BCX70GLT1   BCX70JLT1   BCX70KLT1**

## TYPICAL  STATIC  CHARACTERISTICS
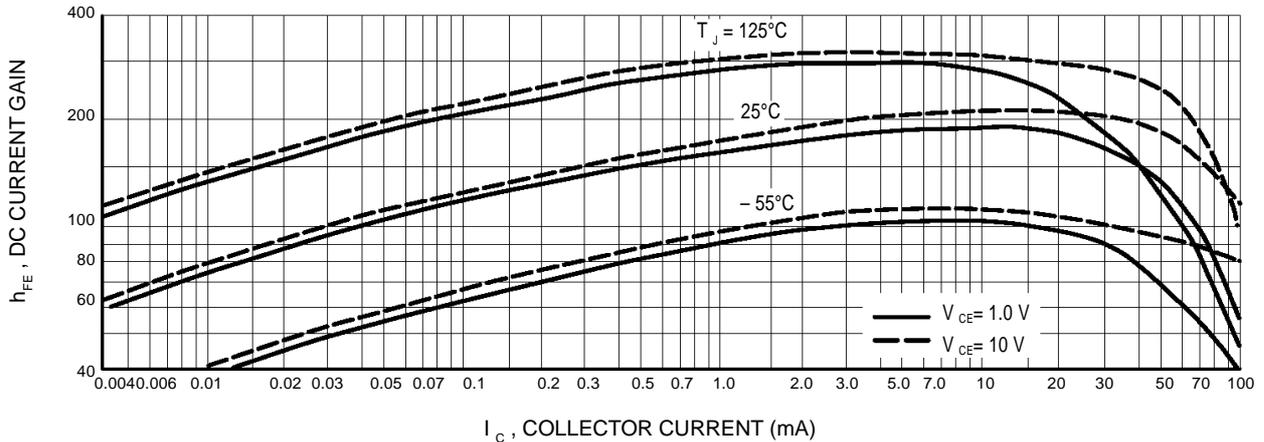


Figure 8. DC Current Gain
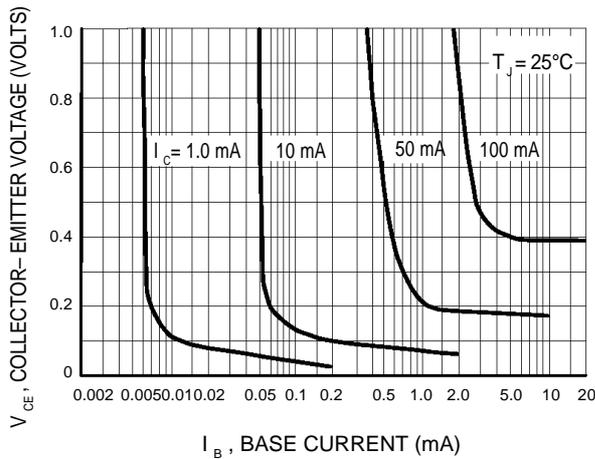


Figure 9. Collector Saturation Region
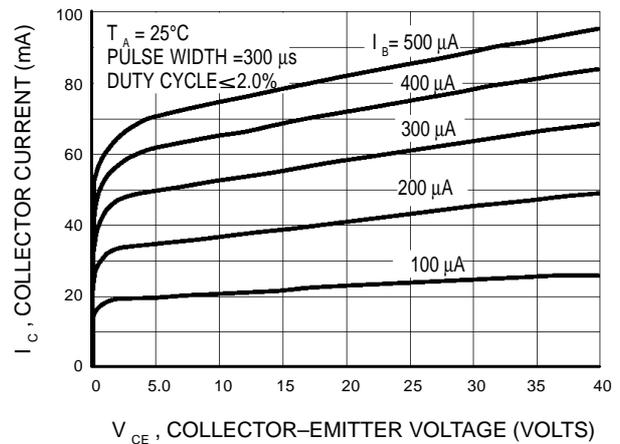


Figure 10. Collector Characteristics
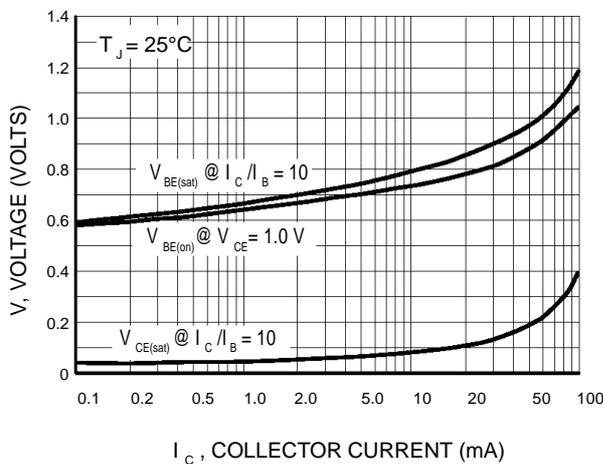


Figure 11. "On" Voltages
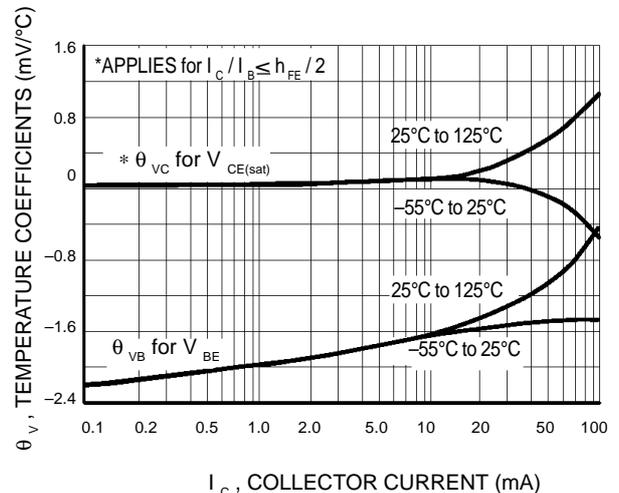


Figure 12. Temperature Coefficients

**BCX70GLT1   BCX70JLT1   BCX70KLT1**

## TYPICAL DYNAMIC CHARACTERISTICS



$V_{CC}$= 3.0 V
$I_C/I_B$= 10
$T_J$= 25°C

$t_f$

$t_d$ @ $V_{BE(off)}$= 0.5 V

$I_C$, COLLECTOR CURRENT (mA)

**Figure 13. Turn–On Time**



$t_s$

$t_f$

$V_{CC}$= 3.0 V
$I_C/I_B$= 10
$I_{B1}$=$I_{B2}$
$T_J$= 25°C

$I_C$, COLLECTOR CURRENT (mA)

**Figure 14. Turn–Off Time**



$T_J$ = 25°C
f=100MHz

$V_{CE}$=20 V

5.0 V

$I_C$, COLLECTOR CURRENT (mA)
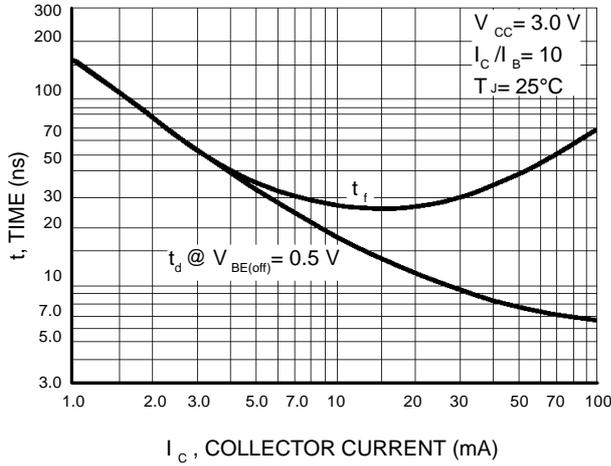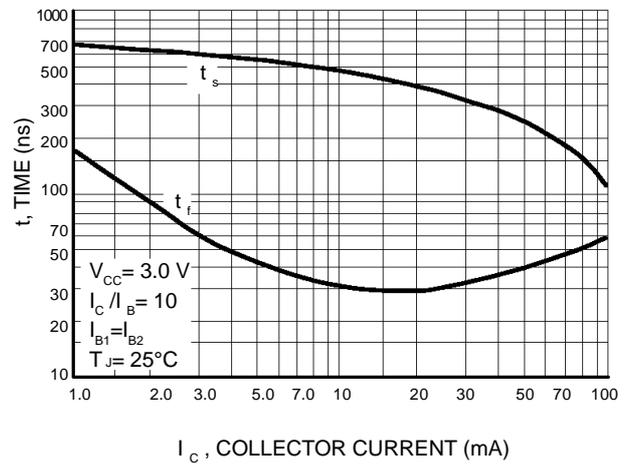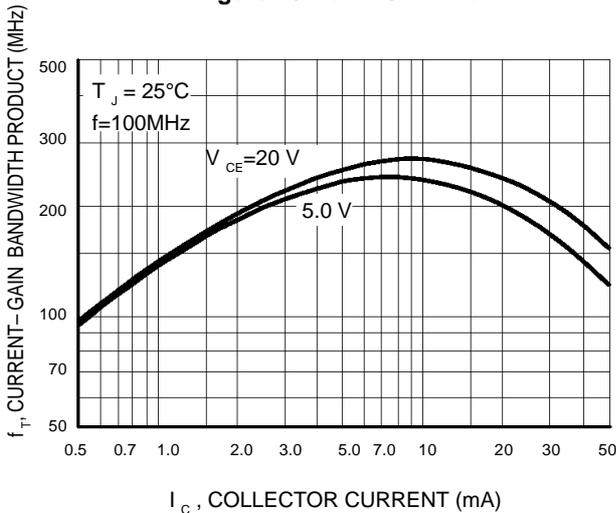
**Figure 15. Current–Gain — Bandwidth Product**



$T_J$= 25°C
f = 1.0MHz

$C_{ib}$

$C_{ob}$

$V_R$, REVERSE VOLTAGE (VOLTS)

**Figure 16. Capacitance**



$V_{CE}$= 10 Vdc
f = 1.0 kHz
$T_A$ = 25°C

$h_{fe} \simeq$ 200 @ $I_C$= 1.0 mA

$I_C$, COLLECTOR CURRENT (mA)
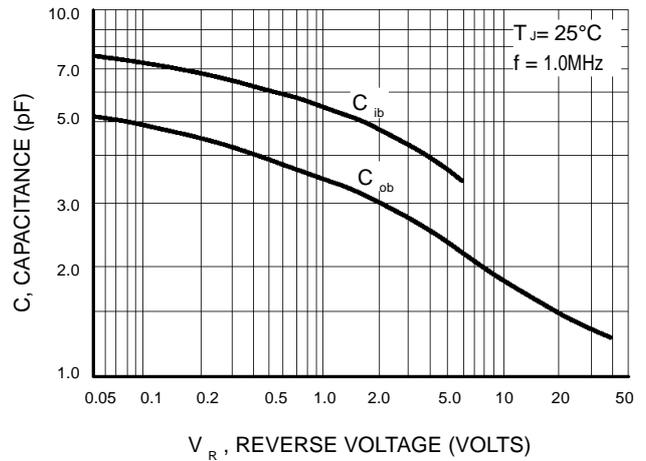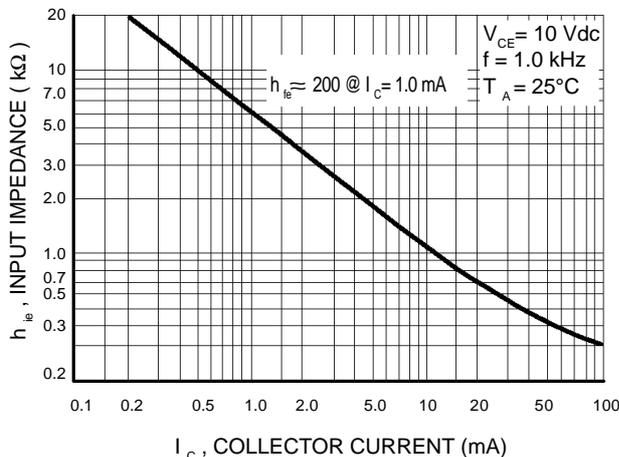
**Figure 17. Input Impedance**



$V_{CE}$= 10 Vdc
f = 1.0 kHz
$T_A$ = 25°C

$h_{fe} \simeq$ 200 @ $I_C$= 1.0 mA

$I_C$, COLLECTOR CURRENT (mA)
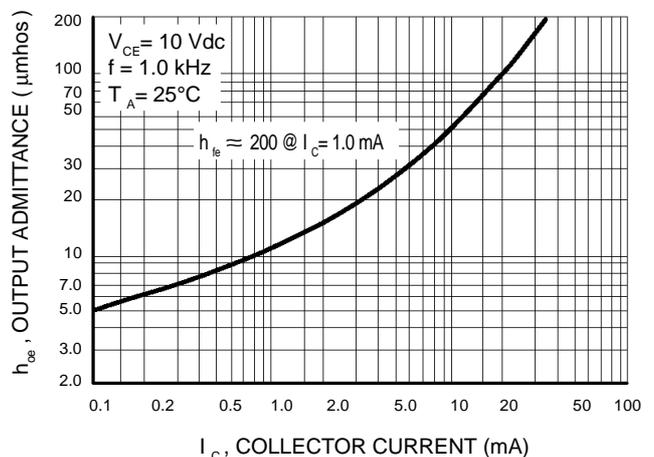
**Figure 18. Output Admittance**

**BCX70GLT1   BCX70JLT1   BCX70KLT1**



FIGURE 19A   DUTY CYCLE, D = $t_1 / t_2$
D CURVES APPLY FOR POWER
PULSE TRAIN SHOWN
READ TIME AT $t_1$ (SEE AN–569)
$Z_{\theta JA(t)} = r(t) \cdot R_{\theta JA}$
$T_{J(pk)} - T_A = P_{(pk)} Z_{\theta JA(t)}$
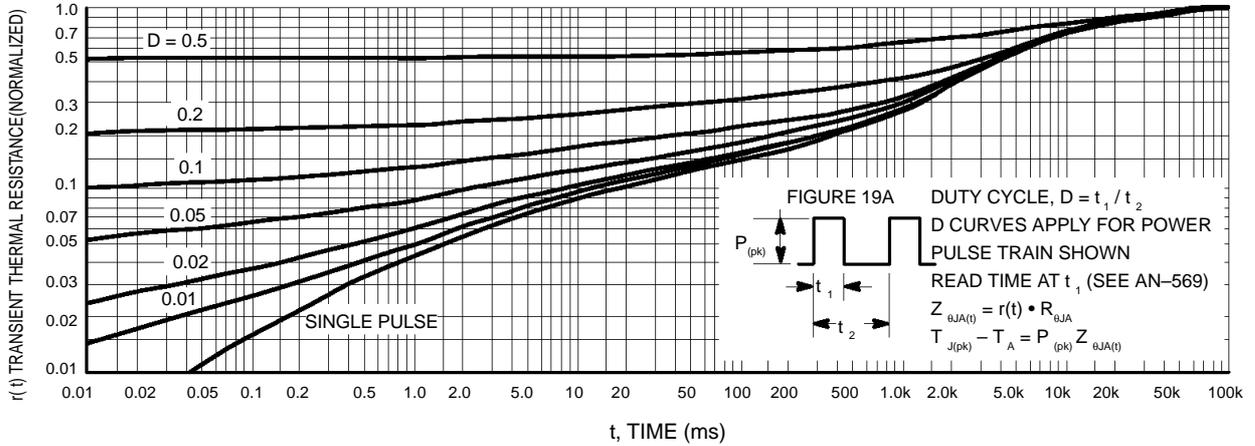
**Figure 19. Thermal Response**



$T_J$ , JUNCTION TEMPERATURE (°C)

**Figure 19A.**



$V_{CE}$ , COLLECTOR–EMITTER VOLTAGE  (VOLTS)
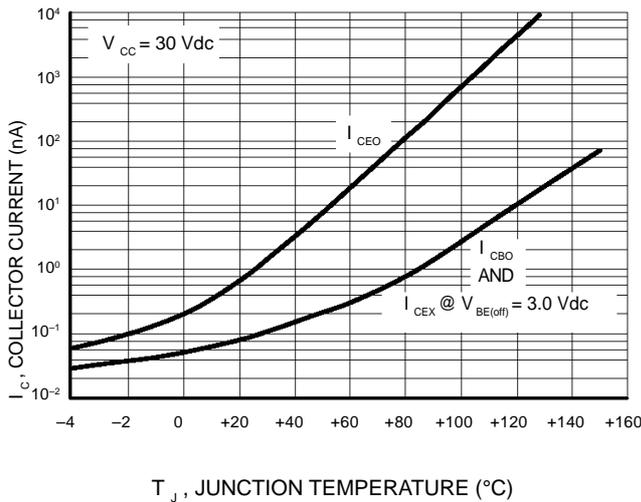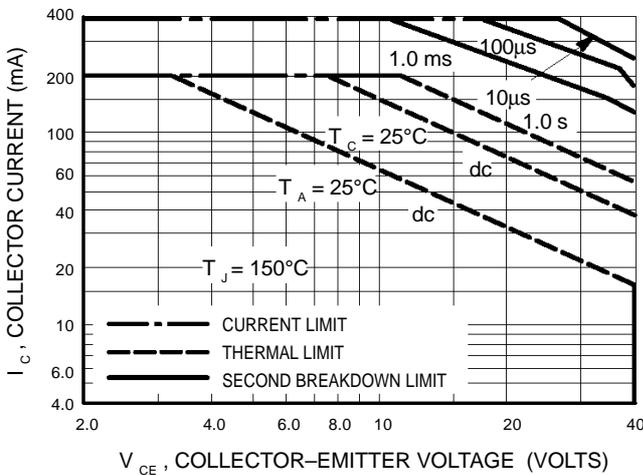
**Figure 20.**

**DESIGN NOTE: USE OF THERMAL RESPONSE DATA**

A train of periodical power pulses can be represented by the model as shown in Figure 19A. Using the model and the device thermal response the normalized effective transient thermal resistance of Figure 19 was calculated for various duty cycles.

To find $Z_{\theta JA(t)}$ , multiply the value obtained from Figure 19 by the steady state value $R_{\theta JA}$ .

Example:

The MPS3904 is dissipating 2.0 watts peak under the following conditions:

$t_1$ = 1.0 ms, $t_2$ = 5.0 ms. (D = 0.2)

Using Figure 19 at a pulse width of 1.0 ms and D = 0.2, the reading of r(t) is 0.22.

The peak rise in junction temperature is therefore

$\Delta T$ = r(t) x $P_{(pk)}$ x $R_{\theta JA}$ = 0.22 x 2.0 x 200 = 88°C.

For more information, see AN–569.

The safe operating area curves indicate $I_C$ –$V_{CE}$ limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 20 is based upon $T_{J(pk)}$ = 150°C; $T_C$ or $T_A$ is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150$°C. $T_{J(pk)}$ may be calculated from the data in Figure 19. At high case or ambient temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.