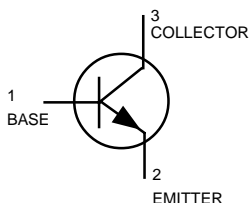


General Purpose Transistors

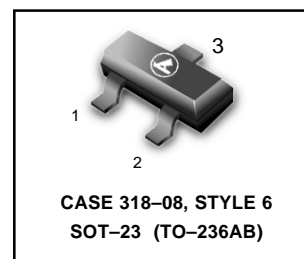
NPN Silicon



BCW60ALT1
BCW60BLT1
BCW60DLT1

MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|--------------------------------|-----------|-------|------|
| Collector–Emitter Voltage | V_{CEO} | 32 | Vdc |
| Collector–Base Voltage | V_{CBO} | 32 | Vdc |
| Emitter–Base Voltage | V_{EBO} | 5.0 | Vdc |
| Collector Current — Continuous | I_C | 100 | mAdc |



THERMAL CHARACTERISTICS

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

DEVICE MARKING

BCW60ALT1 = AA, BCW60BLT1 = AB, BCW60DLT1 = AD

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

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

OFF CHARACTERISTICS

| | | | | |
|--|---------------|-----|----|-------------------------|
| Collector–Emitter Breakdown Voltage ($I_C = 2.0\text{mAdc}, I_E = 0$) | $V_{(BR)CEO}$ | 32 | — | Vdc |
| Emitter–Base Breakdown Voltage ($I_E = 1.0\ \mu\text{Adc}, I_C = 0$) | $V_{(BR)EBO}$ | 5.0 | — | Vdc |
| Collector Cutoff Current ($V_{CE} = 32\ \text{Vdc},$) ($V_{CE} = 32\ \text{Vdc}, T_A = 150^\circ\text{C}$) | I_{CES} | — | 20 | nAdc μAdc |
| Emitter Cutoff Current ($I_{EB} = 4.0\ \text{Vdc}, I_C = 0$) | 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.

BCW60ALT1 BCW60BLT1 BCW60DLT1

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted) (Continued)

| Characteristic | Symbol | Min | Max | Unit |
|--|---------------|-----|------|------|
| ON CHARACTERISTICS | | | | |
| DC Current Gain ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5.0 \text{ Vdc}$) | h_{FE} | | | — |
| | BCW60A | 20 | — | |
| | BCW60B | 30 | — | |
| | BCW60D | 100 | — | |
| ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) | h_{FE} | | | — |
| | BCW60A | 120 | 220 | |
| | BCW60B | 175 | 310 | |
| | BCW60D | 380 | 630 | |
| ($I_C = 50 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) | h_{FE} | | | — |
| | BCW60A | 60 | — | |
| | BCW60B | 70 | — | |
| | BCW60D | 100 | — | |
| AC Current Gain ($V_{CE} = 5.0 \text{ Vdc}$, $I_C = 2.0 \text{ mAdc}$, $f = 1.0 \text{ kHz}$) | h_{FE} | | | — |
| | BCW60A | 125 | 250 | |
| | BCW60B | 175 | 350 | |
| | BCW60D | 350 | 700 | |
| Collector–Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 1.25 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}$, $I_B = 0.25 \text{ mAdc}$) | $V_{CE(sat)}$ | | | Vdc |
| | | — | 0.55 | |
| | | — | 0.35 | |
| Base–Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 1.25 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 0.25 \text{ mAdc}$) | $V_{BE(sat)}$ | | | Vdc |
| | | 0.7 | 1.05 | |
| | | 0.6 | 0.85 | |
| Base–Emitter On Voltage ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) | $V_{BE(on)}$ | | | Vdc |
| | | 0.6 | 0.75 | |

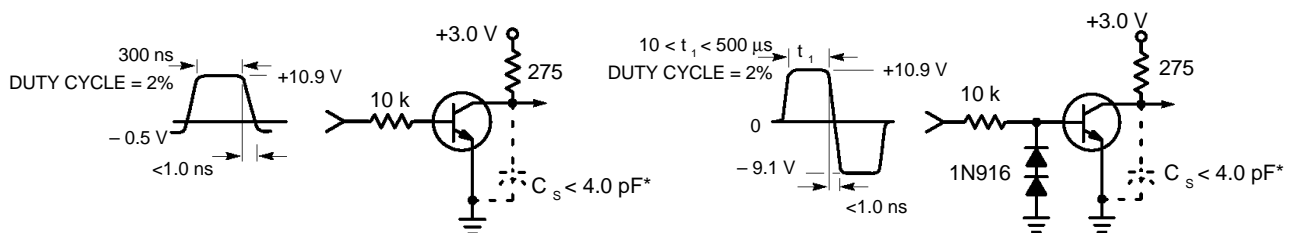
SMSMALL–SIGNAL CHARACTERISTICS

| | | | | |
|---|-----------|-----|-----|-----|
| Current–Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 100 \text{ MHz}$) | f_T | 125 | — | MHz |
| Output Capacitance ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$) | C_{obo} | — | 4.5 | pF |
| Noise Figure ($V_{CE} = 5.0 \text{ Vdc}$, $I_C = 0.2 \text{ mAdc}$, $R_S = 2.0 \text{ k}\Omega$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$) | NF | — | 6.0 | dB |

SWITCHING CHARACTERISTICS

| | | | | |
|--|-----------|---|-----|----|
| Turn–On Time ($I_C = 10 \text{ mAdc}$, $I_{B1} = 1.0 \text{ mAdc}$) | t_{on} | — | 150 | ns |
| Turn–Off Time ($I_{B2} = 1.0 \text{ mAdc}$, $V_{BB} = 3.6 \text{ Vdc}$, $R_1 = R_2 = 5.0 \text{ k}\Omega$, $R_L = 990 \Omega$) | t_{off} | — | 800 | ns |

EQUIVALENT SWITCHING TIME TEST CIRCUITS



*Total shunt capacitance of test jig and connectors

Figure 1. Turn–On Time

Figure 2. Turn–Off Time

BCW60ALT1 BCW60BLT1 BCW60DLT1

TYPICAL NOISE CHARACTERISTICS

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

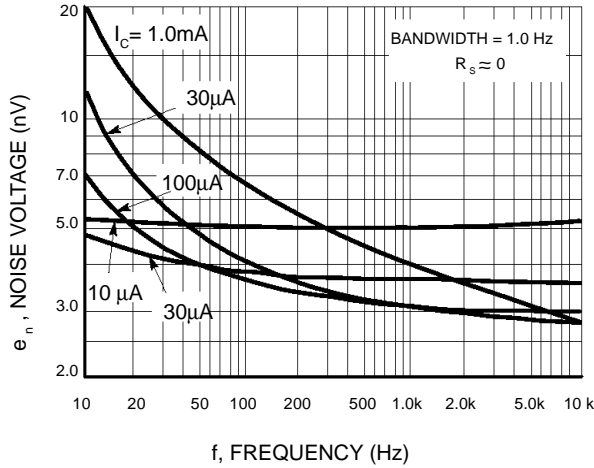


Figure 3. Noise Voltage

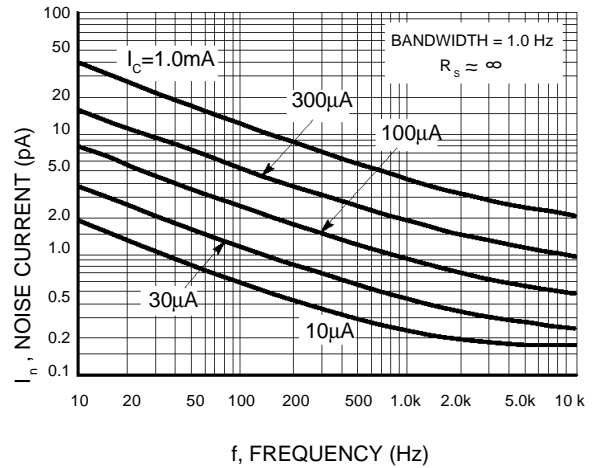


Figure 4. Noise Current

NOISE FIGURE CONTOURS

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

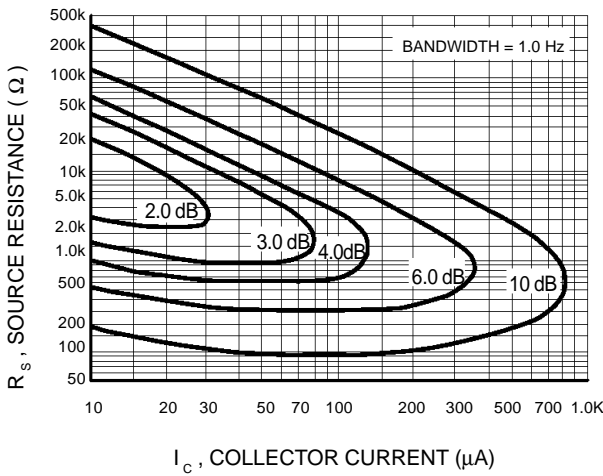


Figure 5. Narrow Band, 100 Hz

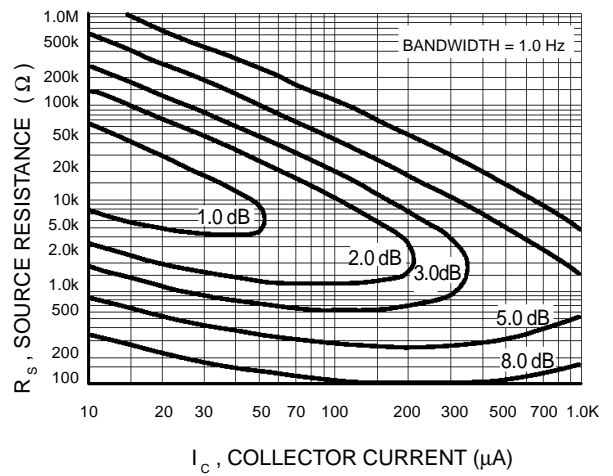


Figure 6. Narrow Band, 1.0 kHz

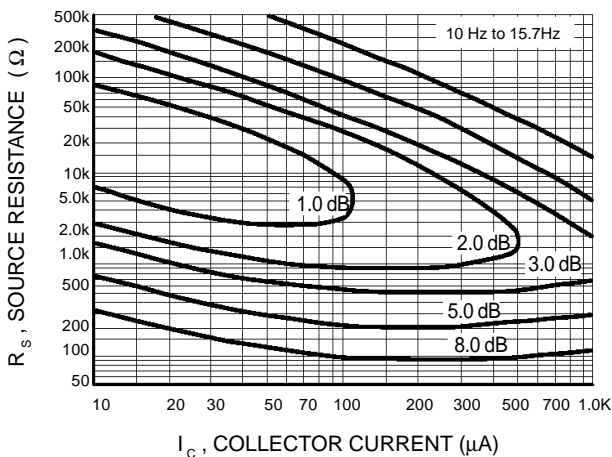


Figure 7. Wideband

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 ($1.38 \times 10^{-23} \text{ J}^\circ\text{K}$)
- T = Temperature of the Source Resistance ($^\circ\text{K}$)
- R_s = Source Resistance (Ω)

BCW60ALT1 BCW60BLT1 BCW60DLT1

TYPICAL NOISE CHARACTERISTICS

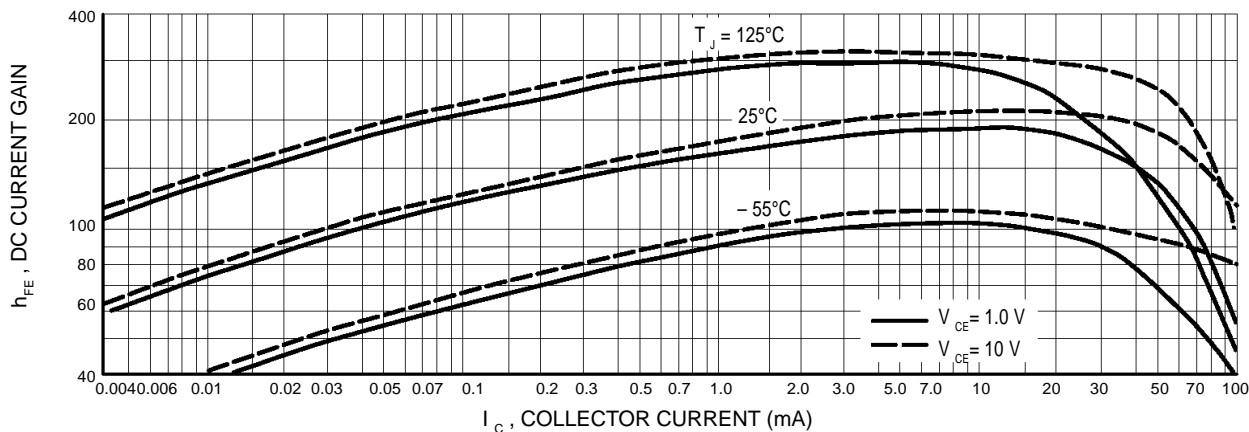


Figure 8. DC Current Gain

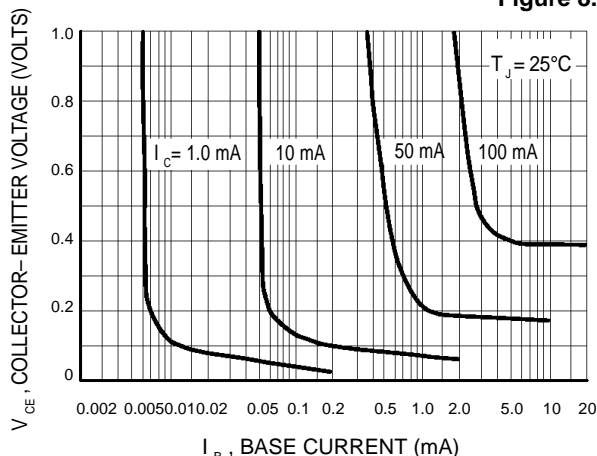


Figure 9. Collector Saturation Region

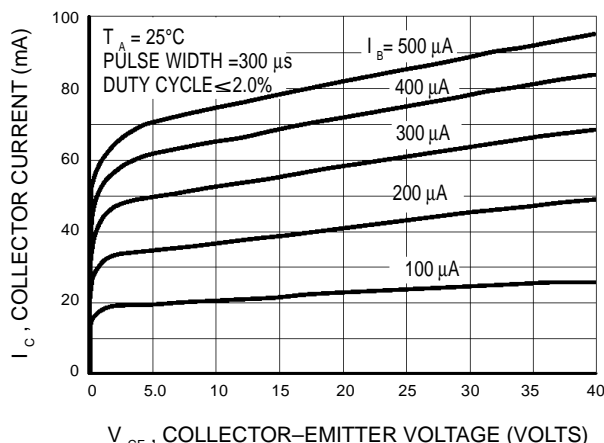


Figure 10. Collector Characteristics

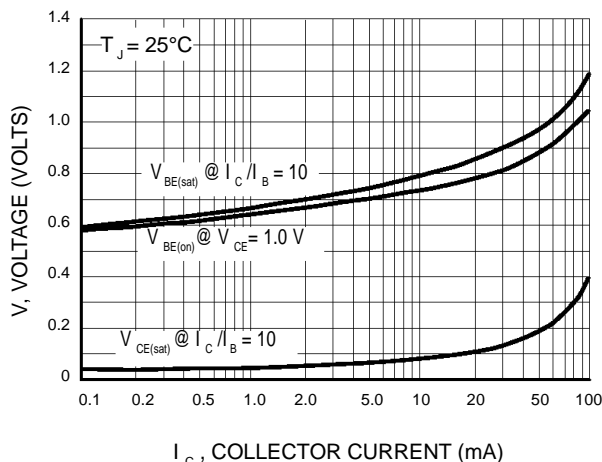


Figure 11. "On" Voltages

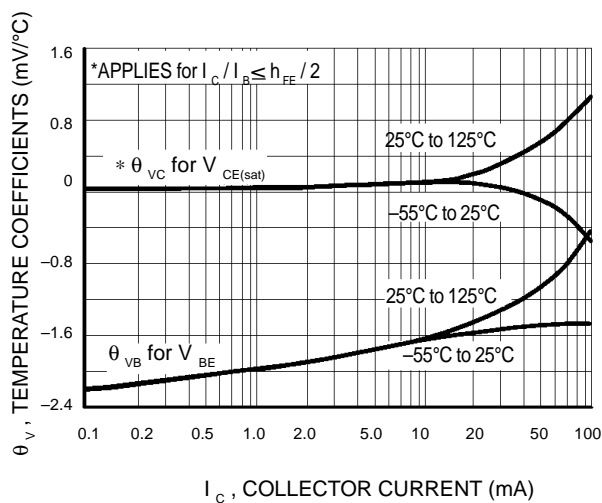
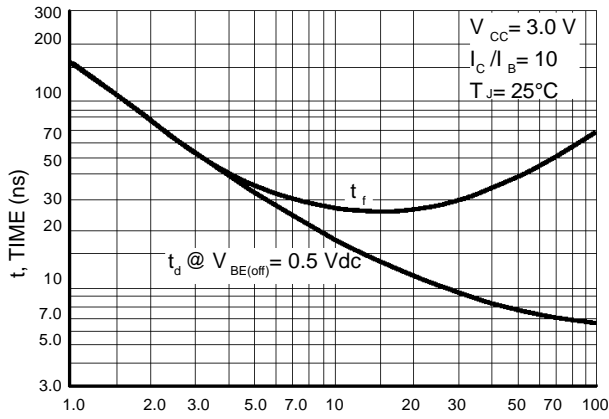


Figure 12. Temperature Coefficients

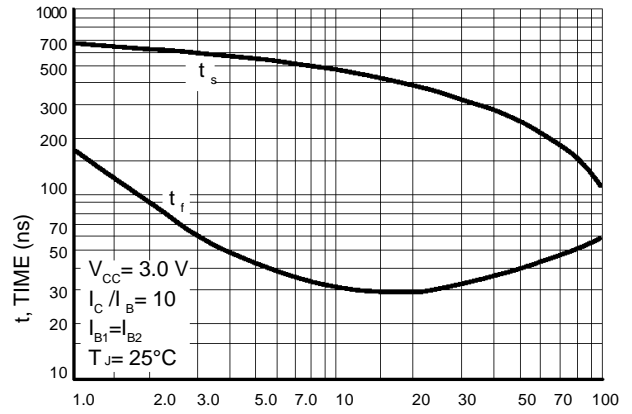
BCW60ALT1 BCW60BLT1 BCW60DLT1

TYPICAL DYNAMIC CHARACTERISTICS



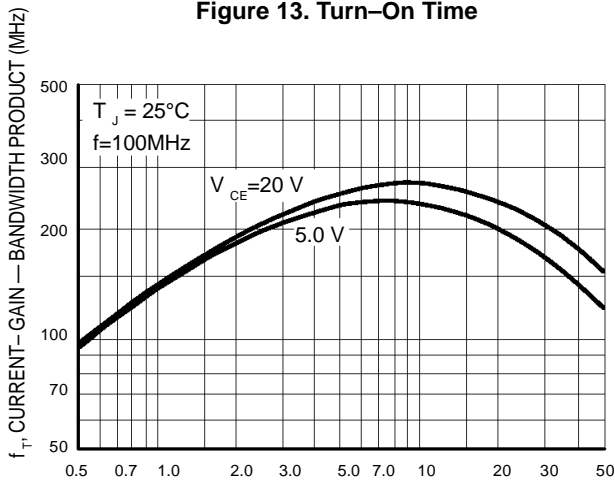
I_C , COLLECTOR CURRENT (mA)

Figure 13. Turn-On Time



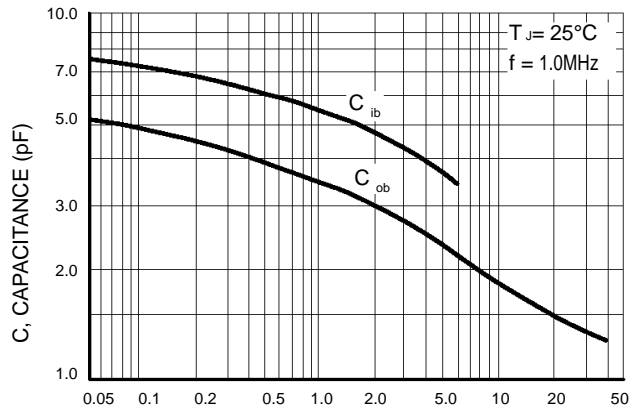
I_C , COLLECTOR CURRENT (mA)

Figure 14. Turn-Off Time



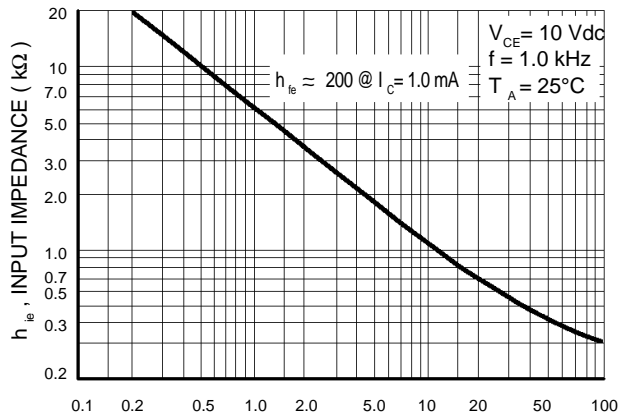
I_C , COLLECTOR CURRENT (mA)

Figure 15. Current-Gain — Bandwidth Product



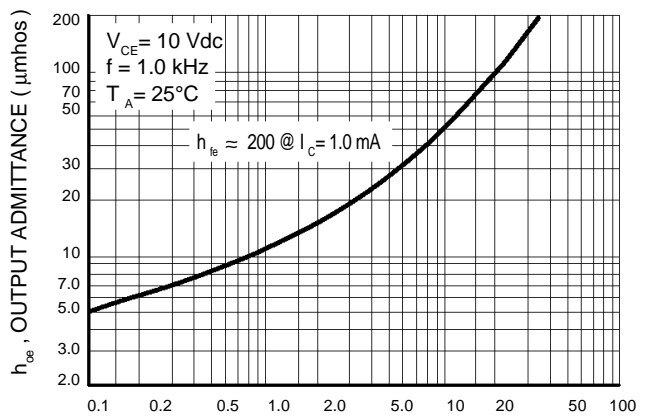
V_R , REVERSE VOLTAGE (VOLTS)

Figure 16. Capacitance



I_C , COLLECTOR CURRENT (mA)

Figure 17. Input Impedance



I_C , COLLECTOR CURRENT (mA)

Figure 18. Output Admittance

BCW60ALT1 BCW60BLT1 BCW60DLT1

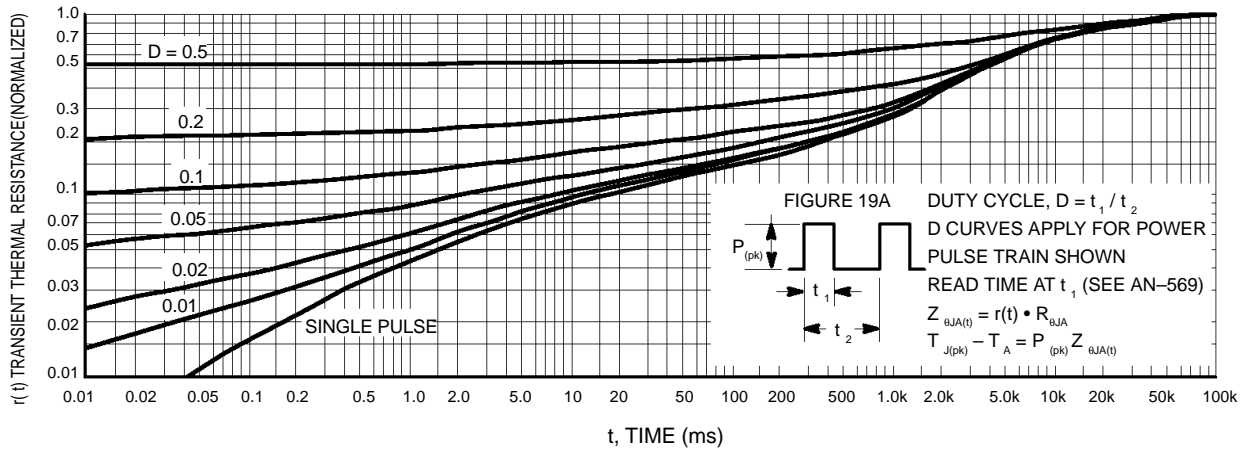


Figure 19. Thermal Response

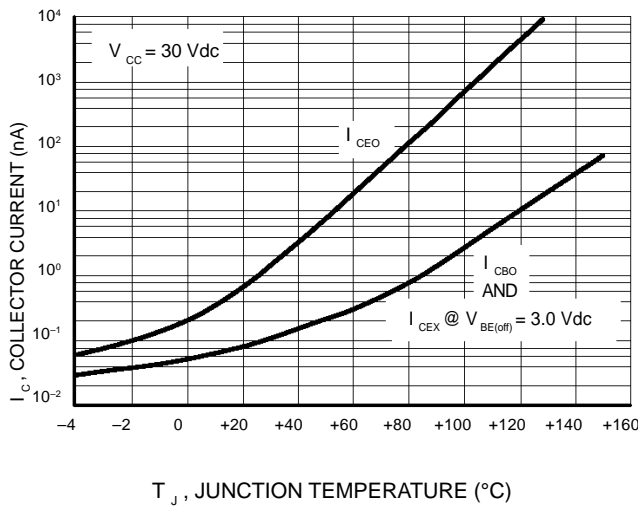


Figure 19A.

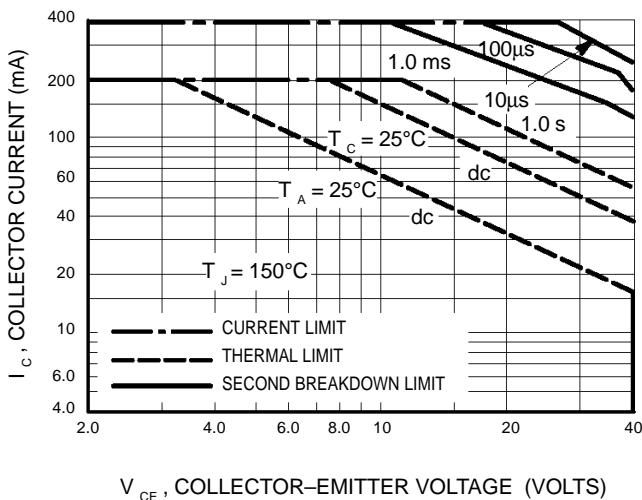


Figure 20.

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:

$$t_1 = 1.0 \text{ ms}, t_2 = 5.0 \text{ ms. (D = 0.2)}$$

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

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

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 $T_{J(pk)} = 150^{\circ}C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^{\circ}C$. $T_{J(pk)}$ 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.



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