

# MOTOROLA SEMICONDUCTOR TECHNICAL DATA

## DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for general purpose and low speed switching applications.

- High DC Current Gain –  $h_{FE} = 2500$  (typ.) @  $I_C = 5.0$  Adc.
- Collector Emitter Sustaining Voltage @ 30 mAdc:  
 $V_{CEO(sus)} = 45$  Vdc (min.) – BDW39/BDW44  
 60 Vdc (min.) – BDW40/BDW45  
 80 Vdc (min.) – BDW41/BDW46  
 100 Vdc (min.) – BDW42/BDW47  
 120 Vdc (min.) – BDW43/BDW48
- Low Collector Emitter Saturation Voltage:  
 $V_{CE(sat)} = 2.0$  Vdc (max.) @  $I_C = 5.0$  Adc  
 3.0 Vdc (max.) @  $I_C = 10.0$  Adc
- Monolithic Construction with Built-In Base Emitter Shunt resistors
- TO-220AB Compact Package
- TO-66 Lead form also available ordered with "-66" suffix.

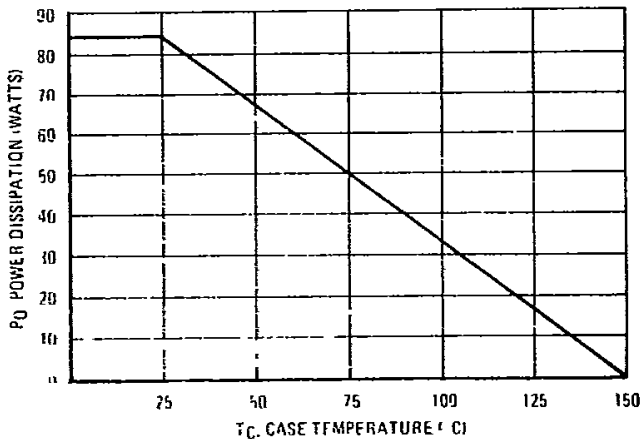
### MAXIMUM RATINGS

| Rating  | Symbol         | BDW39<br>BDW44 | BDW40<br>BDW45 | BDW41<br>BDW46 | BDW42<br>BDW47 | BDW43<br>BDW48 | Unit         |
|---|----------------|----------------|----------------|----------------|----------------|----------------|--------------|
| Collector-Emitter Voltage                                     | $V_{CEO}$      | 45             | 60             | 80             | 100            | 120            | Vdc          |
| Collector-Base Voltage  | $V_{CB}$       | 45             | 60             | 80             | 100            | 120            | Vdc          |
| Emitter-Base Voltage  | $V_{EB}$       | 5.0            |                |                |                |                | Vdc          |
| Collector Current – Continuous                                | $I_C$          | 15             |                |                |                |                | Adc          |
| Base Current  | $I_B$          | 0.5            |                |                |                |                | Adc          |
| Total Device Dissipation<br>$T_C = 25$ C<br>Derate above 25 C | $P_D$          | 85             |                |                | 0.68           |                | Watts<br>W/C |
| Operating and Storage Junction<br>Temperature Range           | $T_J, T_{stg}$ | -55 to -150    |                |                |                |                | C            |

### THERMAL CHARACTERISTICS

| Characteristic                       | Symbol          | Max. | Unit |
|--------------------------------------|-----------------|------|------|
| Thermal Resistance, Junction to Case | $R_{\theta JC}$ | 1.47 | C/W  |

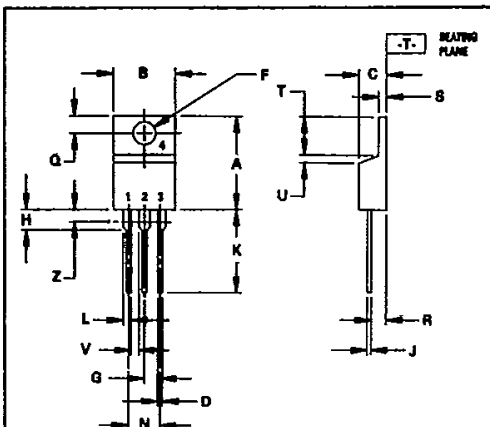
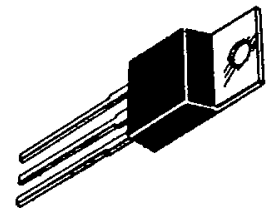
FIGURE 1 – POWER TEMPERATURE DERATING CURVE



**NPN  
BDW39  
thru  
BDW43**

**PNP  
BDW44  
thru  
BDW48**

**DARLINGTON  
15 AMPERE  
COMPLEMENTARY SILICON  
POWER TRANSISTORS  
45-60-80-100-120 VOLTS  
85 WATTS**



- NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 2. CONTROLLING DIMENSION INCH.  
 3. DIM Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 14.48       | 15.75 | 0.570  | 0.620 |
| B   | 9.66        | 10.28 | 0.380  | 0.405 |
| C   | 4.07        | 4.82  | 0.160  | 0.190 |
| D   | 0.64        | 0.98  | 0.025  | 0.035 |
| F   | 3.61        | 3.73  | 0.142  | 0.147 |
| G   | 2.42        | 2.66  | 0.095  | 0.105 |
| H   | 2.90        | 3.93  | 0.110  | 0.155 |
| J   | 0.48        | 0.71  | 0.018  | 0.028 |
| K   | 12.70       | 14.27 | 0.500  | 0.562 |
| L   | 1.15        | 1.39  | 0.045  | 0.055 |
| N   | 4.80        | 5.33  | 0.190  | 0.210 |
| Q   | 2.54        | 3.04  | 0.100  | 0.120 |
| R   | 2.04        | 2.79  | 0.080  | 0.110 |
| S   | 1.15        | 1.39  | 0.045  | 0.055 |
| T   | 5.97        | 8.47  | 0.235  | 0.335 |
| U   | 0.00        | 1.27  | 0.000  | 0.050 |
| V   | 1.15        | —     | 0.045  | —     |
| Z   | —           | 2.04  | —      | 0.080 |

- STYLE 1  
 PIN 1 BASE  
 2. COLLECTOR  
 3. EMITTER  
 4. COLLECTOR

**CASE 221A-04  
TO-220AB**

## BDW39, BDW40, BDW41, BDW42, BDW43 NPN BDW44, BDW45, BDW46, BDW47, BDW48 PNP

### ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

| Characteristic  | Symbol                     | Min  | Max | Unit |
|---|----------------------------|------|-----|------|
| <b>OFF CHARACTERISTICS</b>  |                            |      |     |      |
| Collector Emitter Sustaining Voltage (1)<br>(I <sub>C</sub> = 30 mAdc, I <sub>B</sub> = 0)  | V <sub>CEO(sus)</sub>      |      |     | Vdc  |
| BDW39/BDW44   |                            | 45   | —   |      |
| BDW40/BDW45   |                            | 60   | —   |      |
| BDW41/BDW46   |                            | 80   | —   |      |
| BDW42/BDW47   |                            | 100  | —   |      |
| BDW43/BDW48   |                            | 120  | —   |      |
| Collector Cutoff Current<br>(V <sub>CE</sub> = 22.5 Vdc, I <sub>B</sub> = 0)  | I <sub>CEO</sub>           | —    | 2.0 | mAdc |
| (V <sub>CE</sub> = 30 Vdc, I <sub>B</sub> = 0)  |                            | —    | 2.0 |      |
| (V <sub>CE</sub> = 40 Vdc, I <sub>B</sub> = 0)  |                            | —    | 2.0 |      |
| (V <sub>CE</sub> = 50 Vdc, I <sub>B</sub> = 0)  |                            | —    | 2.0 |      |
| (V <sub>CE</sub> = 60 Vdc, I <sub>B</sub> = 0)  |                            | —    | 2.0 |      |
| Collector Cutoff Current<br>(V <sub>CB</sub> = 45 Vdc, I <sub>E</sub> = 0)  | I <sub>CBO</sub>           | —    | 1.0 | mAdc |
| (V <sub>CB</sub> = 60 Vdc, I <sub>E</sub> = 0)  |                            | —    | 1.0 |      |
| (V <sub>CB</sub> = 80 Vdc, I <sub>E</sub> = 0)  |                            | —    | 1.0 |      |
| (V <sub>CB</sub> = 100 Vdc, I <sub>E</sub> = 0)   |                            | —    | 1.0 |      |
| (V <sub>CB</sub> = 120 Vdc, I <sub>E</sub> = 0)   |                            | —    | 1.0 |      |
| Emitter Cutoff Current<br>(V <sub>BE</sub> = 5.0 Vdc, I <sub>C</sub> = 0)   | I <sub>EBO</sub>           | —    | 2.0 | mAdc |
| <b>ON CHARACTERISTICS (1)</b>   |                            |      |     |      |
| DC Current Gain<br>(I <sub>C</sub> = 5.0 Adc, V <sub>CE</sub> = 4.0 Vdc)  | h <sub>FE</sub>            | 1000 | —   |      |
| (I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)  |                            | 250  | —   |      |
| Collector-Emitter Saturation Voltage<br>(I <sub>C</sub> = 5.0 Adc, I <sub>B</sub> = 10 mAdc)  | V <sub>CE(sat)</sub>       | —    | 2.0 | Vdc  |
| (I <sub>C</sub> = 10 Adc, I <sub>B</sub> = 50 mAdc)   |                            | —    | 3.0 |      |
| Base-Emitter On Voltage<br>(I <sub>C</sub> = 10 Adc, V <sub>CE</sub> = 4.0 Vdc)   | V <sub>BE(on)</sub>        | —    | 3.0 | Vdc  |
| <b>SECOND BREAKDOWN (2)</b>   |                            |      |     |      |
| Second Breakdown Collector<br>Current with Base Forward Biased  | I <sub>S/b</sub>           |      |     | Adc  |
| BDW39/BDW40/BDW41/BDW42/BDW43   | V <sub>CE</sub> = 28.4 Vdc | 3.0  | —   |      |
|   | V <sub>CE</sub> = 40 Vdc   | 1.2  | —   |      |
| BDW44/BDW45/BDW46/BDW47/BDW48   | V <sub>CE</sub> = 22.5 Vdc | 3.8  | —   |      |
|   | V <sub>CE</sub> = 36 Vdc   | 1.2  | —   |      |
| <b>DYNAMIC CHARACTERISTICS</b>  |                            |      |     |      |
| Magnitude of common emitter small signal short circuit current transfer ratio<br>(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 MHz) | f <sub>T</sub>             | 4.0  | —   | MHz  |
| Output Capacitance<br>(V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0, f = 0.1 MHz)   | C <sub>ob</sub>            |      |     | pF   |
| BDW39/BDW40/BDW41/BDW42/BDW43   |                            | —    | 200 |      |
| BDW44/BDW45/BDW46/BDW47/BDW48   |                            | —    | 300 |      |
| Small-Signal Current Gain<br>(I <sub>C</sub> = 3.0 Adc, V <sub>CE</sub> = 3.0 Vdc, f = 1.0 kHz)   | h <sub>fe</sub>            | 300  | —   |      |

Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

(2) Pulse Test non repetitive: Pulse Width = 250 ms.

# BDW39, BDW40, BDW41, BDW42, BDW43 NPN BDW44, BDW45, BDW46, BDW47, BDW48 PNP

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT

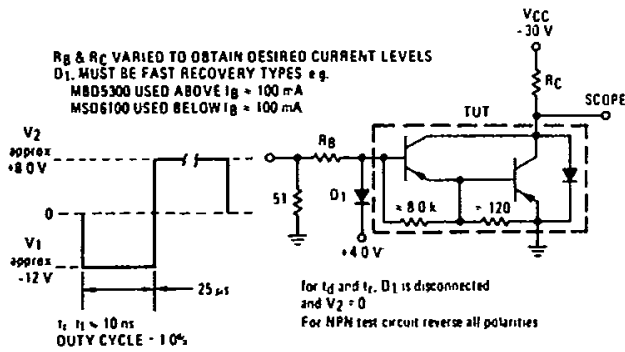


FIGURE 3 – SWITCHING TIMES

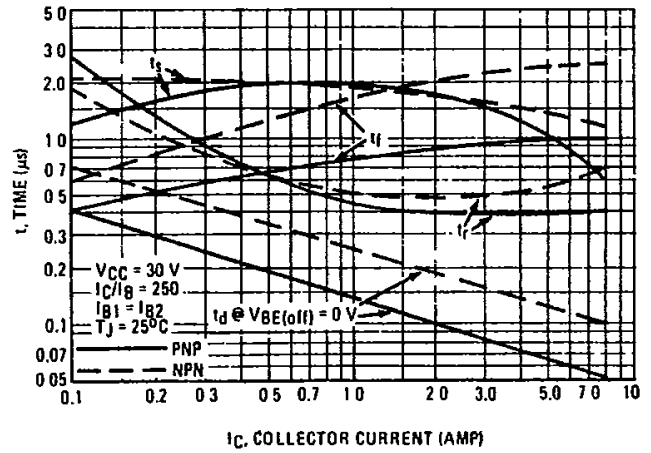
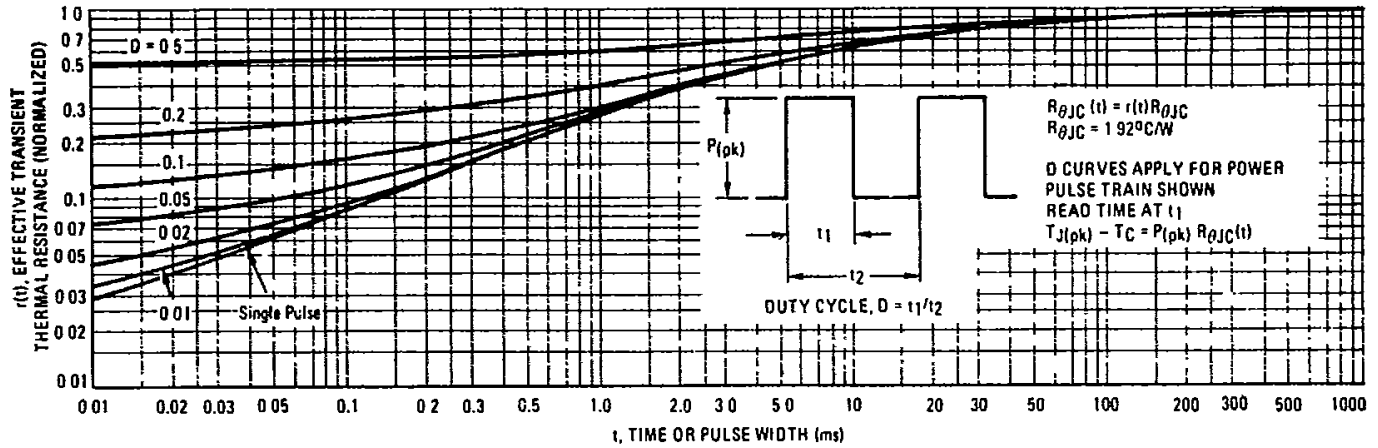
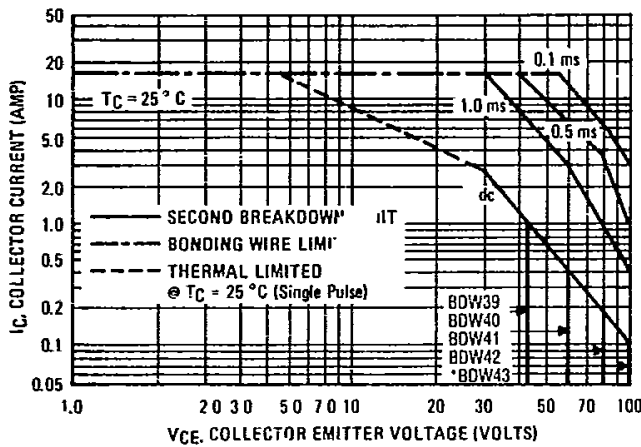


FIGURE 4 – THERMAL RESPONSE



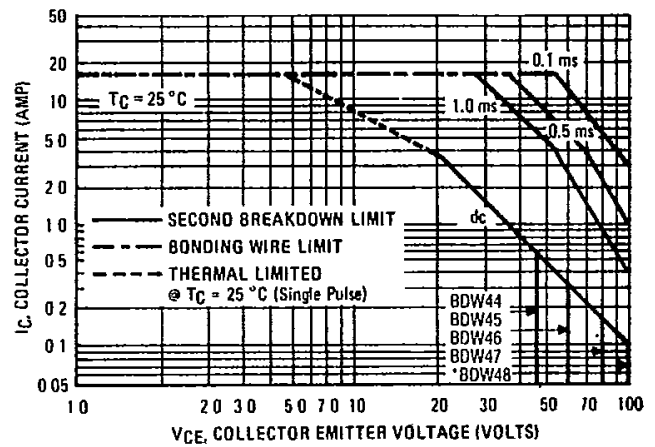
## ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – BDW39 THRU BDW43



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate  $I_C - V_{CE}$  limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Fig. 5 and 6 is based on  $T_{J(pk)} =$

FIGURE 6 – BDW44 THRU BDW48

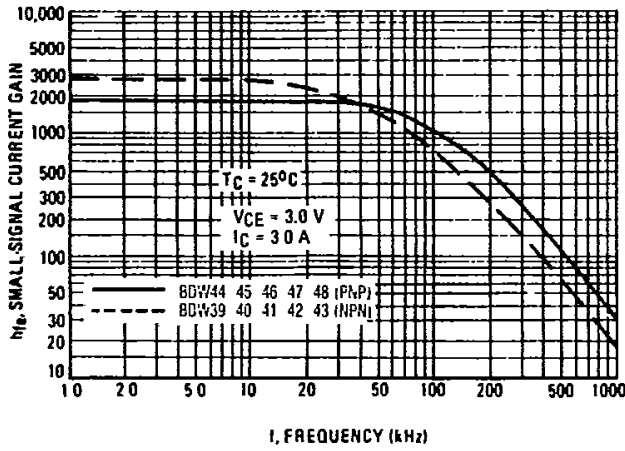


200 °C;  $T_C$  is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided  $T_{J(pk)} \leq 200^\circ\text{C}$ .  $T_{J(pk)}$  may be calculated from the data in Fig. 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See an-415).

\*Linear extrapolation

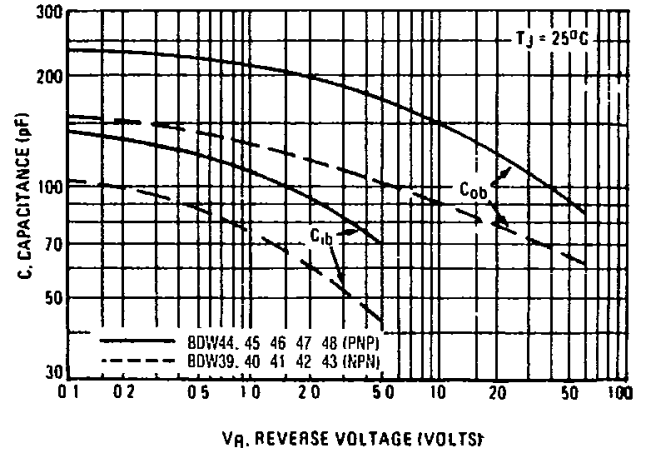
# BDW39, BDW40, BDW41, BDW42, BDW43 NPN BDW44, BDW45, BDW46, BDW47, BDW48 PNP

FIGURE 7 – SMALL-SIGNAL CURRENT GAIN



BDW39, 40, 41, 42, 43 (NPN)

FIGURE 8 – CAPACITANCE



BDW44, 45, 46, 47, 48 (PNP)

FIGURE 9 – DC CURRENT GAIN

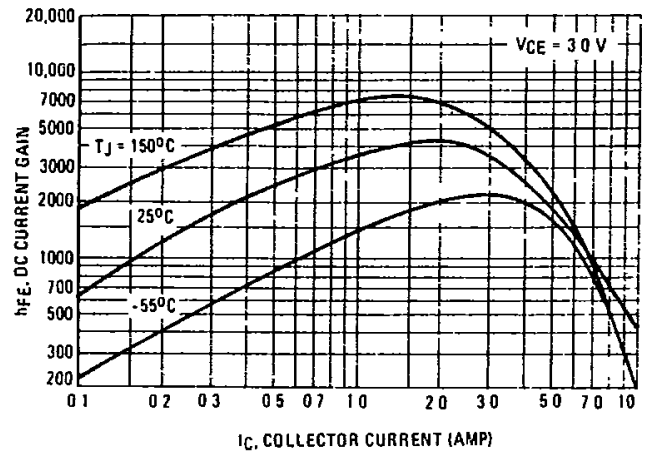
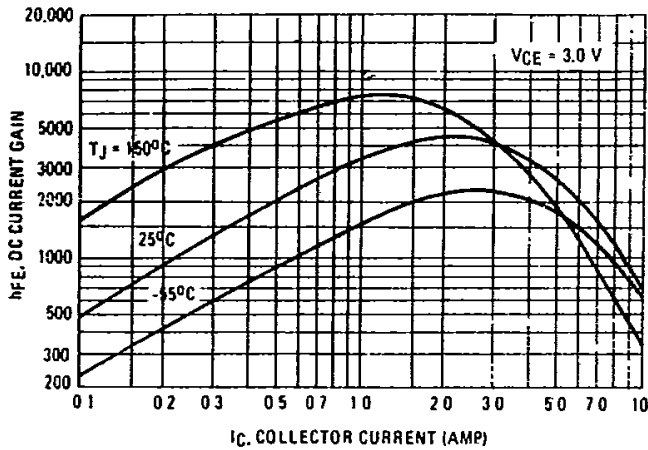
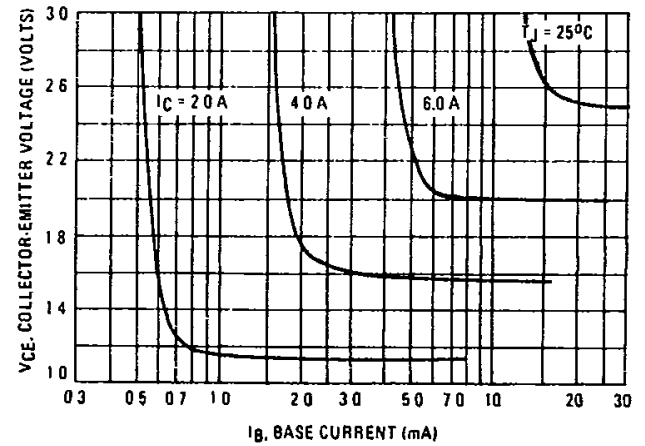
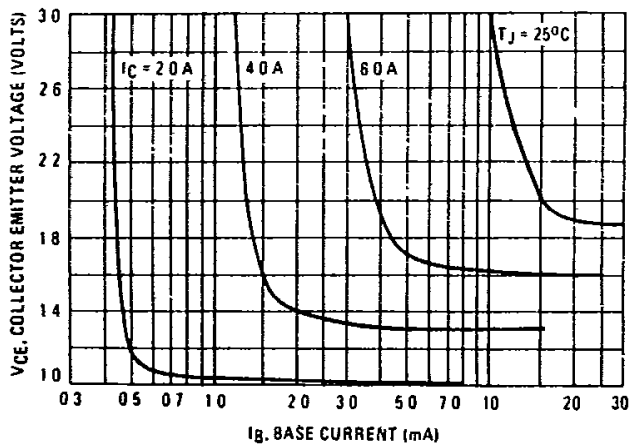


FIGURE 10 – COLLECTOR SATURATION REGION

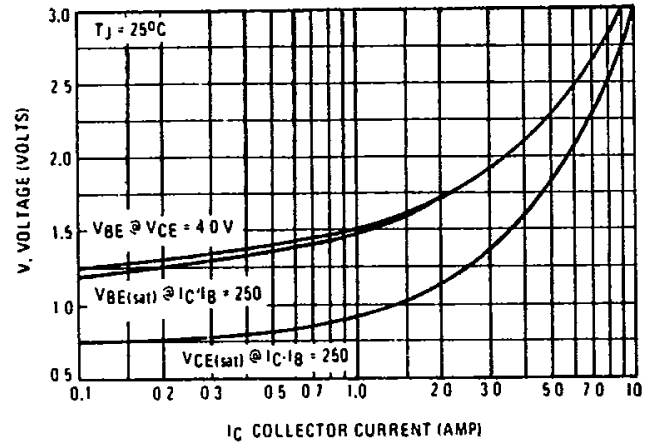
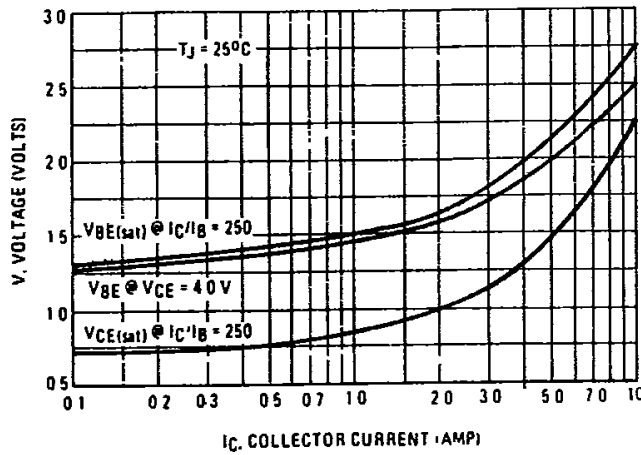


**BDW39, BDW40, BDW41, BDW42, BDW43 NPN**  
**BDW44, BDW45, BDW46, BDW47, BDW48 PNP**

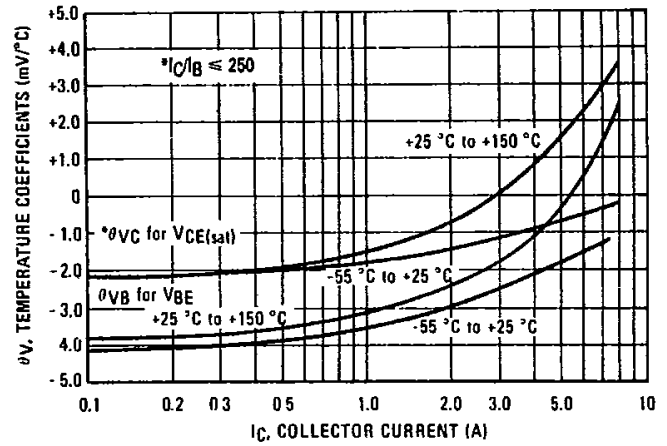
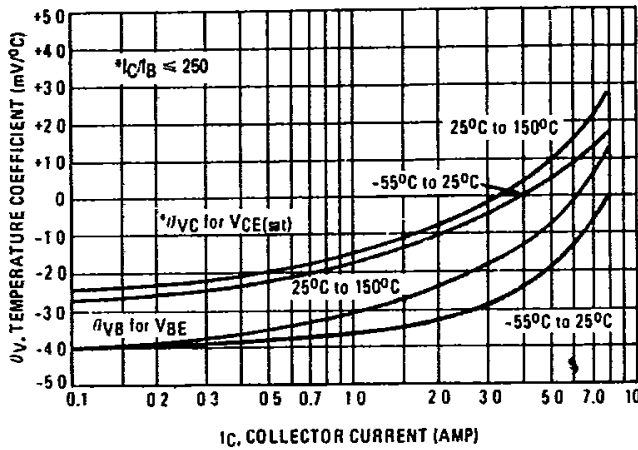
**BDW39, 40, 41, 42, 43 (NPN)**

**BDW44, 45, 46, 47, 48 (PNP)**

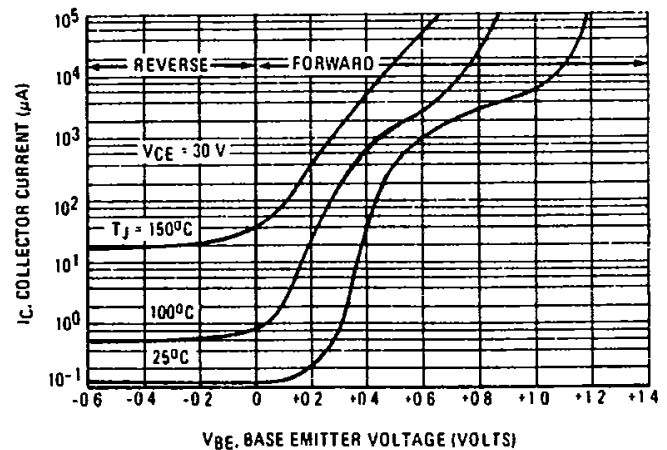
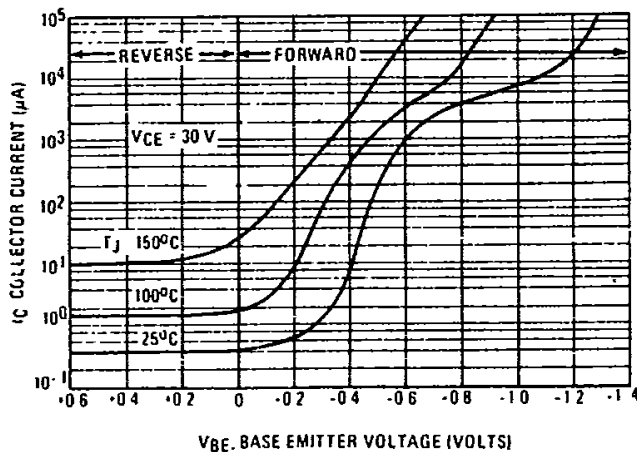
**FIGURE 11 -- "ON" VOLTAGES**



**FIGURE 12 -- TEMPERATURE COEFFICIENTS**



**FIGURE 13 -- COLLECTOR CUT-OFF REGION**



**BDW39, BDW40, BDW41, BDW42, BDW43 NPN**  
**BDW44, BDW45, BDW46, BDW47, BDW48 PNP**

**FIGURE 14 – DARLINGTON SCHEMATIC**

