

MJE18004, MJF18004

Switch-mode NPN Bipolar Power Transistor For Switching Power Supply Applications

The MJE/MJF18004 have an applications specific state-of-the-art die designed for use in 220 V line-operated switch-mode Power supplies and electronic light ballasts.

Features

- Improved Efficiency Due to Low Base Drive Requirements:
 - ◆ High and Flat DC Current Gain h_{FE}
 - ◆ Fast Switching
 - ◆ No Coil Required in Base Circuit for Turn-Off (No Current Tail)
- Full Characterization at 125°C
- ON Semiconductor Six Sigma Philosophy Provides Tight and Reproducible Parametric Distributions
- Two Package Choices: Standard TO-220 or Isolated TO-220
- MJF18004, Case 221D, is UL Recognized at 3500 V_{RMS}: File #E69369
- These Devices are Pb-Free and are RoHS Compliant*

MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|----------------|---|-----------|
| Collector-Emitter Sustaining Voltage | V_{CEO} | 450 | Vdc |
| Collector-Base Breakdown Voltage | V_{CES} | 1000 | Vdc |
| Emitter-Base Voltage | V_{EBO} | 9.0 | Vdc |
| Collector Current – Continuous | I_C | 5.0 | Adc |
| Collector Current – Peak (Note 1) | I_{CM} | 10 | Adc |
| Base Current – Continuous | I_B | 2.0 | Adc |
| Base Current – Peak (Note 1) | I_{BM} | 4.0 | Adc |
| RMS Isolation Voltage (Note 2) Test No. 1 Per Figure 22a Test No. 2 Per Figure 22b Test No. 3 Per Figure 22c (for 1 sec, R.H. < 30%, $T_A = 25^\circ\text{C}$) | V_{ISOL} | MJF18004 4500 3500 1500 | V |
| Total Device Dissipation @ $T_C = 25^\circ\text{C}$ MJE18004 MJF18004 | P_D | 75 35 | W W/°C |
| Derate above 25°C MJE18004 MJF18004 | | 0.6 0.28 | |
| Operating and Storage Temperature | T_J, T_{stg} | -65 to 150 | °C |

THERMAL CHARACTERISTICS

| Characteristics | Symbol | Max | Unit |
|--|-----------------|--------------|------|
| Thermal Resistance, Junction-to-Case MJE18004 MJF18004 | $R_{\theta JC}$ | 1.65 3.55 | °C/W |
| Thermal Resistance, Junction-to-Ambient | $R_{\theta JA}$ | 62.5 | °C/W |
| Maximum Lead Temperature for Soldering Purposes 1/8" from Case for 5 Seconds | T_L | 260 | °C |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

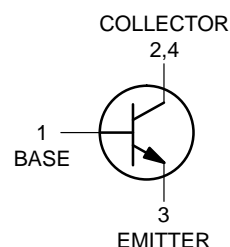
1. Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.
2. Proper strike and creepage distance must be provided.



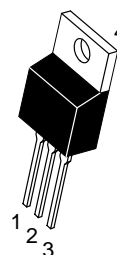
ON Semiconductor®

www.onsemi.com

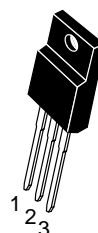
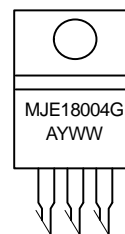
POWER TRANSISTOR
5.0 AMPERES
1000 VOLTS
35 and 75 WATTS



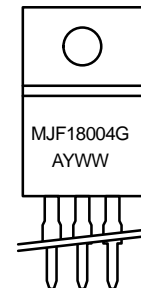
MARKING DIAGRAMS



TO-220AB
CASE 221A-09
STYLE 1



TO-220 FULLPACK
CASE 221D
STYLE 2
UL RECOGNIZED



G = Pb-Free Package
A = Assembly Location
Y = Year
WW = Work Week

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 8 of this data sheet.

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise specified)

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

OFF CHARACTERISTICS

| | | | | | |
|--|----------------|-----|---|-------------------|---|
| Collector–Emitter Sustaining Voltage ($I_C = 100\text{ mA}$, $L = 25\text{ mH}$) | $V_{CEO(sus)}$ | 450 | – | – | Vdc |
| Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $I_B = 0$) | I_{CEO} | – | – | 100 | μAdc |
| Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CES}$, $V_{EB} = 0$) ($V_{CE} = 800\text{ V}$, $V_{EB} = 0$) | I_{CES} | – | – | 100 500 100 | μAdc |
| | | | | | (T _C = 25°C) (T _C = 125°C) (T _C = 125°C) |
| Emitter Cutoff Current ($V_{EB} = 9.0\text{ Vdc}$, $I_C = 0$) | I_{EBO} | – | – | 100 | μAdc |

ON CHARACTERISTICS

| | | | | | |
|--|---------------|----|------------------------------------|-----------------------------------|--|
| Base–Emitter Saturation Voltage ($I_C = 1.0\text{ Adc}$, $I_B = 0.1\text{ Adc}$) ($I_C = 2.0\text{ Adc}$, $I_B = 0.4\text{ Adc}$) | $V_{BE(sat)}$ | – | 0.82 0.92 | 1.1 1.25 | Vdc |
| Collector–Emitter Saturation Voltage ($I_C = 1.0\text{ Adc}$, $I_B = 0.1\text{ Adc}$) ($I_C = 2.0\text{ Adc}$, $I_B = 0.4\text{ Adc}$) ($I_C = 2.5\text{ Adc}$, $I_B = 0.5\text{ Adc}$) | $V_{CE(sat)}$ | – | 0.25 0.29 0.3 0.36 0.5 | 0.5 0.6 0.45 0.8 0.75 | Vdc |
| | | | | | (T _C = 125°C) (T _C = 125°C) (T _C = 125°C) |
| DC Current Gain ($I_C = 1.0\text{ Adc}$, $V_{CE} = 2.5\text{ Vdc}$) ($I_C = 0.3\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 2.0\text{ Adc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) | h_{FE} | 12 | 21 20 14 6.0 7.5 10 | – – 34 – – – | – |
| | | | | | (T _C = 125°C) (T _C = 125°C) (T _C = 125°C) |

DYNAMIC CHARACTERISTICS

| | | | | | |
|--|----------------|---|---|--------------------------------------|--|
| Current Gain Bandwidth ($I_C = 0.5\text{ Adc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$) | f_T | – | 13 | – | MHz |
| Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$) | C_{ob} | – | 50 | 65 | pF |
| Input Capacitance ($V_{EB} = 8.0\text{ V}$) | C_{ib} | – | 800 | 1000 | pF |
| Dynamic Saturation Voltage: Determined 1.0 μs and 3.0 μs respectively after rising I_{B1} reaches 90% of final I_{B1} (see Figure 18) | $V_{CE(dsat)}$ | – | 6.8 14 2.4 5.6 11.3 15.5 1.3 6.1 | – – – – – – – – | Vdc |
| | | | | | (I _C = 1.0 Adc, I _{B1} = 100 mAdc, V _{CC} = 300 V) (I _C = 2.0 Adc, I _{B1} = 400 mAdc, V _{CC} = 300 V) |
| | | | | | 1.0 μs (T _C = 125°C) 3.0 μs (T _C = 125°C) 1.0 μs (T _C = 125°C) 3.0 μs (T _C = 125°C) |

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ELECTRICAL CHARACTERISTICS — continued ($T_C = 25^\circ\text{C}$ unless otherwise specified)

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

SWITCHING CHARACTERISTICS: Resistive Load ($D.C. \leq 10\%$, Pulse Width = 20 μs)

| | | | | | | |
|---------------|--|-----------|---|------------|-------------|---------------|
| Turn-On Time | ($I_C = 1.0 \text{ Adc}$, $I_{B1} = 0.1 \text{ Adc}$, $I_{B2} = 0.5 \text{ Adc}$, $V_{CC} = 300 \text{ V}$) ($T_C = 125^\circ\text{C}$) | t_{on} | – | 210 180 | 300 – | ns |
| Turn-Off Time | | t_{off} | – | 1.0 1.3 | 1.7 – | μs |
| Turn-On Time | ($I_C = 2.0 \text{ Adc}$, $I_{B1} = 0.4 \text{ Adc}$, $I_{B1} = 1.0 \text{ Adc}$, $V_{CC} = 300 \text{ V}$) ($T_C = 125^\circ\text{C}$) | t_{on} | – | 75 90 | 110 – | ns |
| Turn-Off Time | | t_{off} | – | 1.5 1.8 | 2.5 – | μs |
| Turn-On Time | ($I_C = 2.5 \text{ Adc}$, $I_{B1} = 0.5 \text{ Adc}$, $I_{B2} = 0.5 \text{ Adc}$, $V_{CC} = 250 \text{ V}$) ($T_C = 125^\circ\text{C}$) | t_{on} | – | 450 900 | 800 1400 | ns |
| Storage Time | | t_s | – | 2.0 2.2 | 3.0 3.5 | μs |
| Fall Time | | t_f | – | 275 500 | 400 800 | ns |

SWITCHING CHARACTERISTICS: Inductive Load ($V_{clamp} = 300 \text{ V}$, $V_{CC} = 15 \text{ V}$, $L = 200 \mu\text{H}$)

| | | | | | | |
|----------------|---|----------|---|-------------|------------|---------------|
| Fall Time | ($I_C = 1.0 \text{ Adc}$, $I_{B1} = 0.1 \text{ Adc}$, $I_{B2} = 0.5 \text{ Adc}$) ($T_C = 125^\circ\text{C}$) | t_{fi} | – | 100 100 | 150 – | ns |
| Storage Time | | t_{si} | – | 1.1 1.4 | 1.7 – | μs |
| Crossover Time | | t_c | – | 180 160 | 250 – | ns |
| Fall Time | ($I_C = 2.0 \text{ Adc}$, $I_{B1} = 0.4 \text{ Adc}$, $I_{B2} = 1.0 \text{ Adc}$) ($T_C = 125^\circ\text{C}$) | t_{fi} | – | 90 150 | 175 – | ns |
| Storage Time | | t_{si} | – | 1.7 2.2 | 2.5 – | μs |
| Crossover Time | | t_c | – | 180 250 | 300 – | ns |
| Fall Time | ($I_C = 2.5 \text{ Adc}$, $I_{B1} = 0.5 \text{ Adc}$, $I_{B2} = 0.5 \text{ Adc}$, $V_{BE(off)} = -5.0 \text{ Vdc}$) ($T_C = 125^\circ\text{C}$) | t_{fi} | – | 70 100 | 130 175 | ns |
| Storage Time | | t_{si} | – | 0.75 1.0 | 1.0 1.3 | μs |
| Crossover Time | | t_c | – | 250 250 | 350 500 | ns |

TYPICAL STATIC CHARACTERISTICS

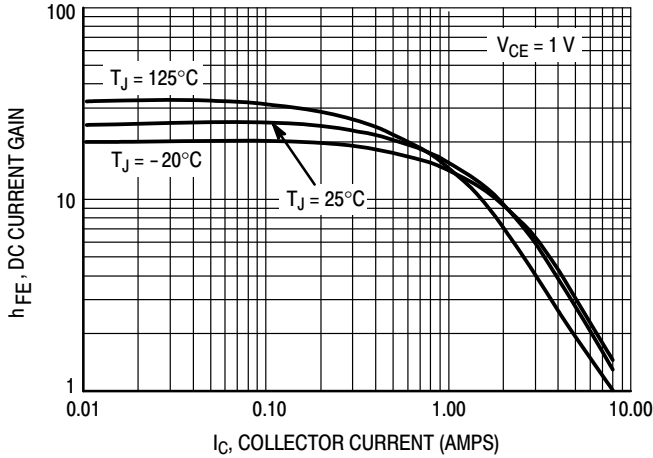


Figure 1. DC Current Gain @ 1 Volt

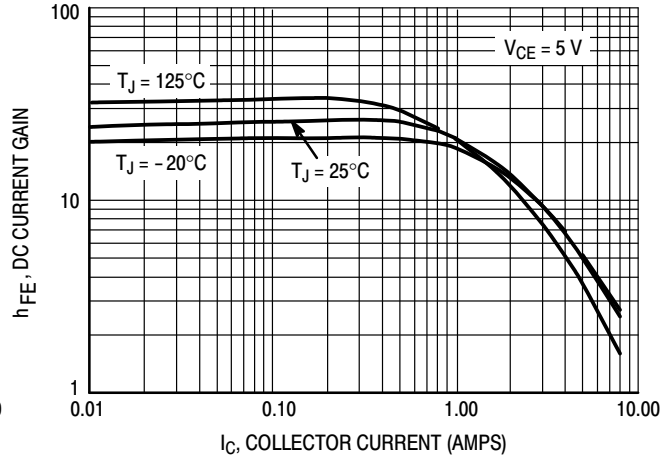


Figure 2. DC Current Gain @ 5 Volts

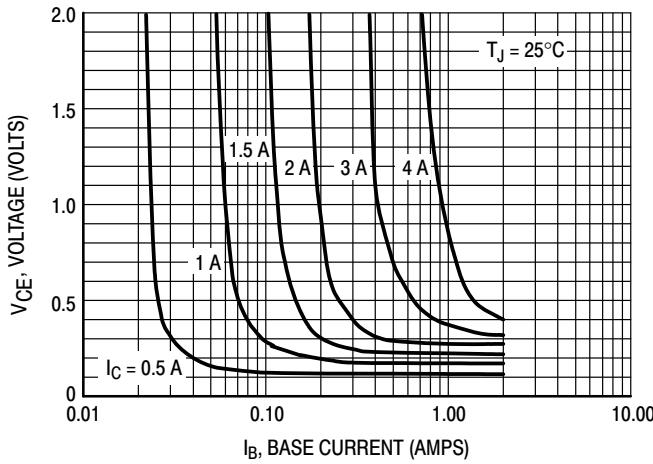


Figure 3. Collector Saturation Region

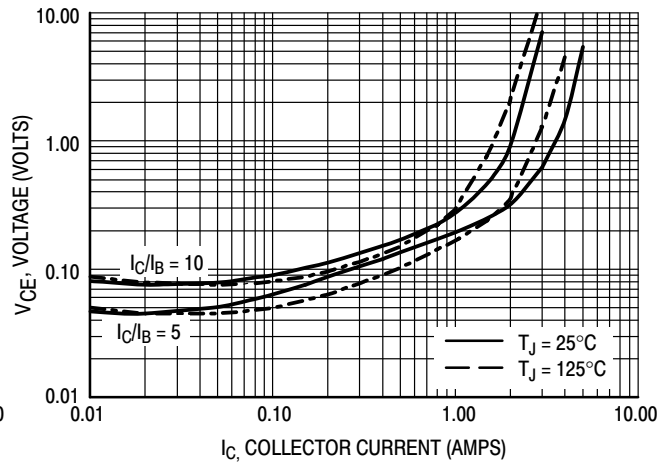


Figure 4. Collector-Emitter Saturation Voltage

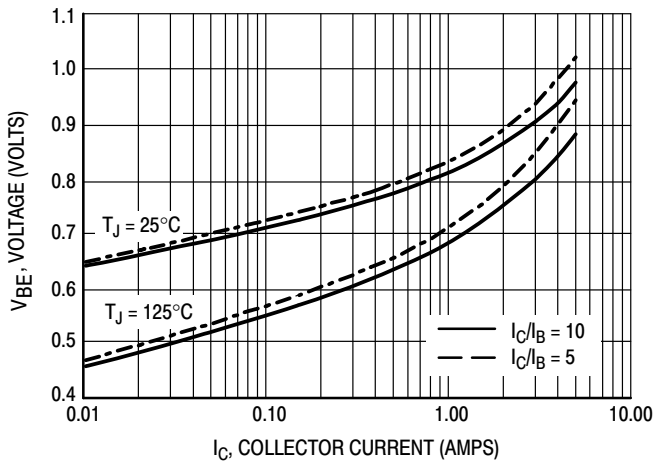


Figure 5. Base-Emitter Saturation Region

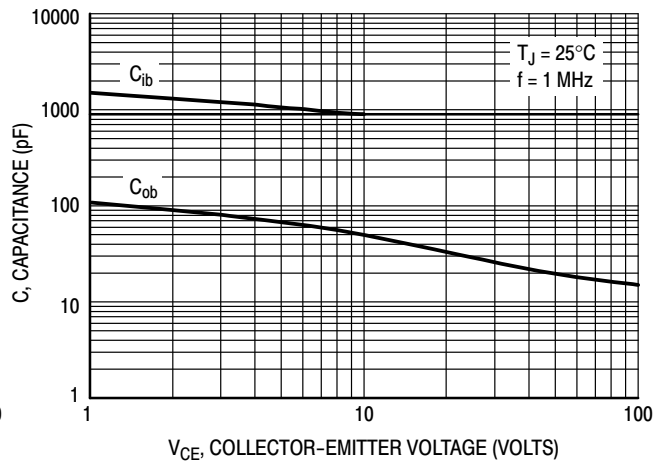


Figure 6. Capacitance

TYPICAL SWITCHING CHARACTERISTICS
($I_{B2} = I_C/2$ for all switching)

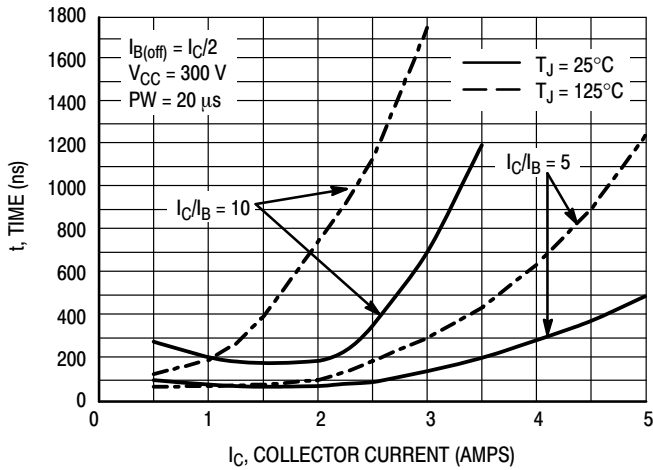


Figure 7. Resistive Switching, t_{on}

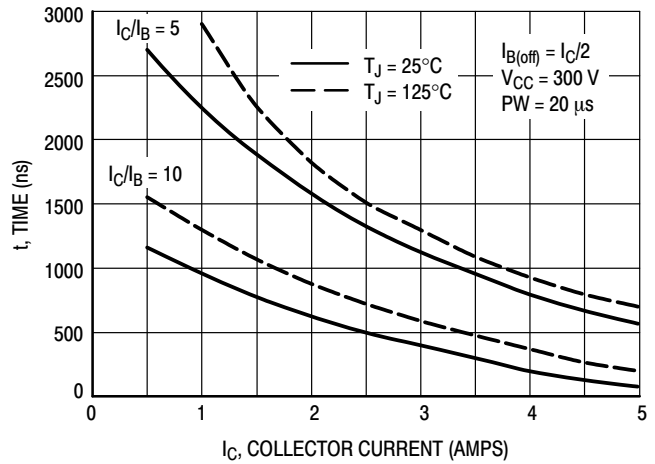


Figure 8. Resistive Switching, t_{off}

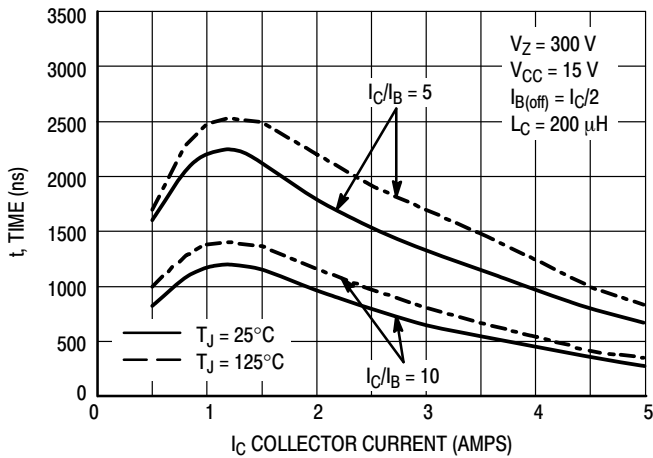


Figure 9. Inductive Storage Time, t_{si}

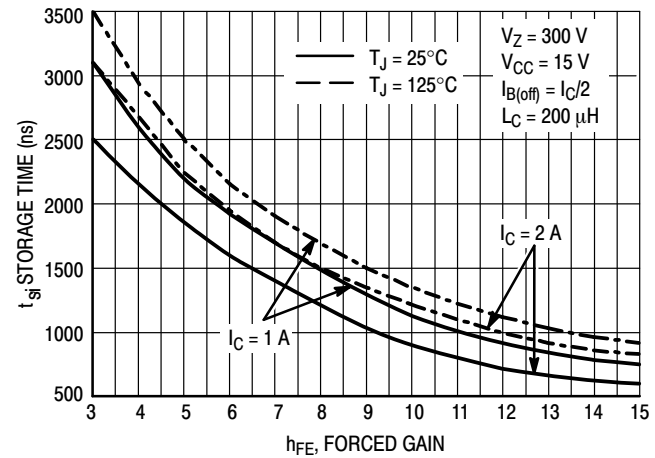


Figure 10. Inductive Storage Time, $t_{si}(h_{FE})$

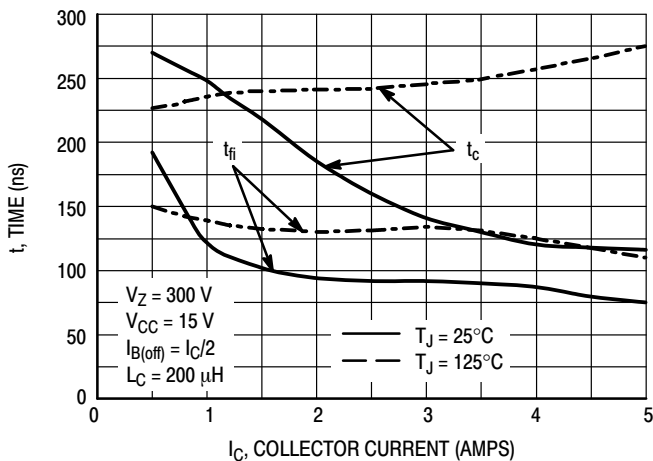


Figure 11. Inductive Switching, t_c and t_{fi} , $I_C/I_B = 5$

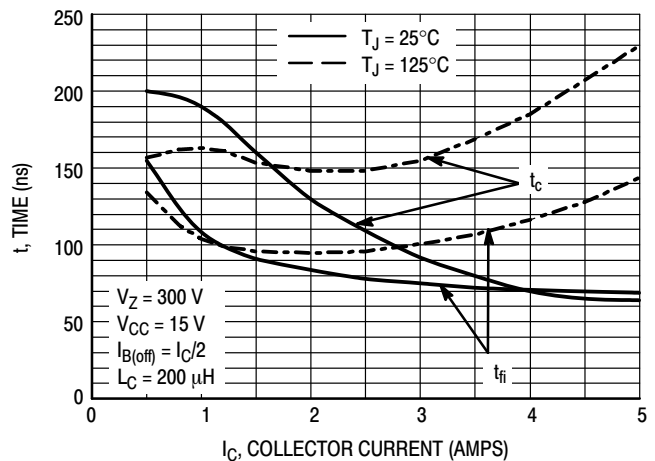


Figure 12. Inductive Switching, t_c and t_{fi} , $I_C/I_B = 10$

TYPICAL SWITCHING CHARACTERISTICS
($I_{B2} = I_C/2$ for all switching)

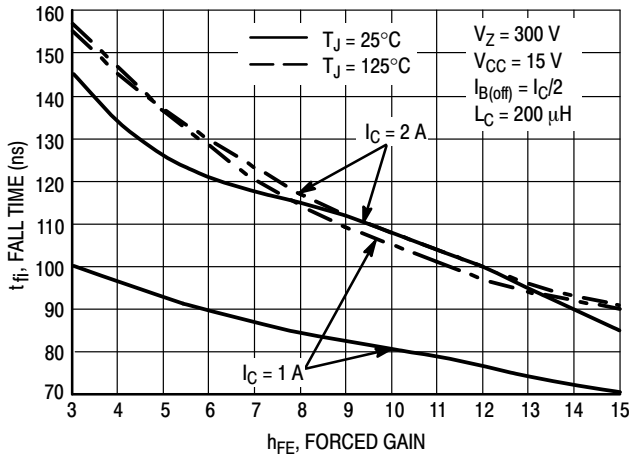


Figure 13. Inductive Fall Time

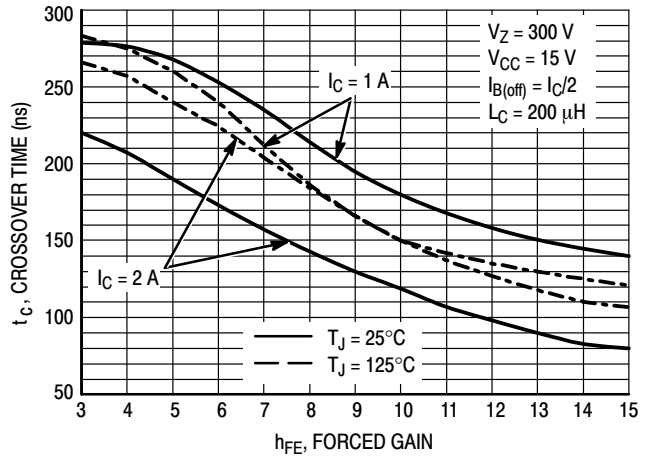


Figure 14. Inductive Crossover Time

GUARANTEED SAFE OPERATING AREA INFORMATION

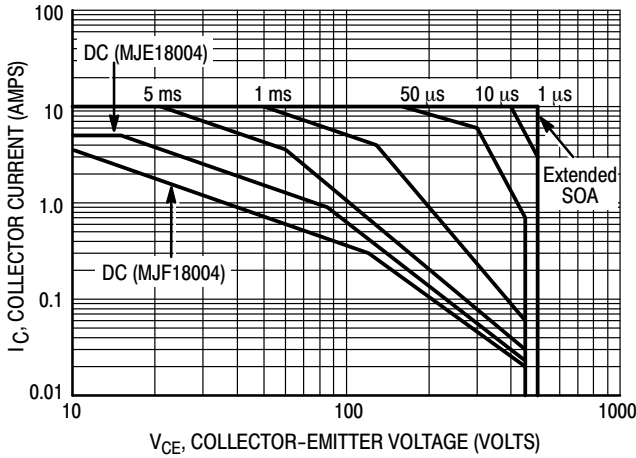


Figure 15. Forward Bias Safe Operating Area

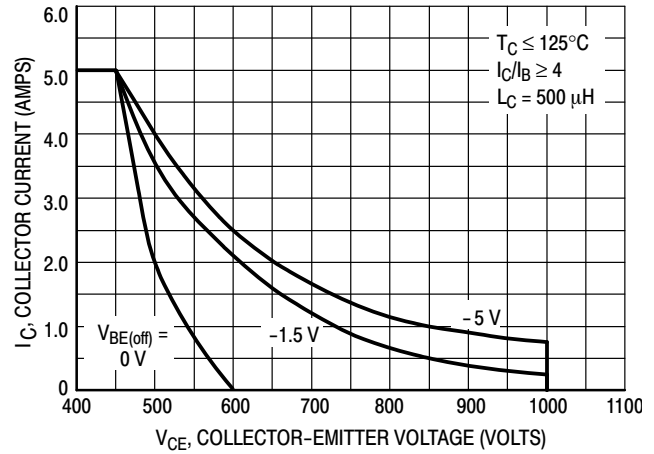


Figure 16. Reverse Bias Safe Operating Area

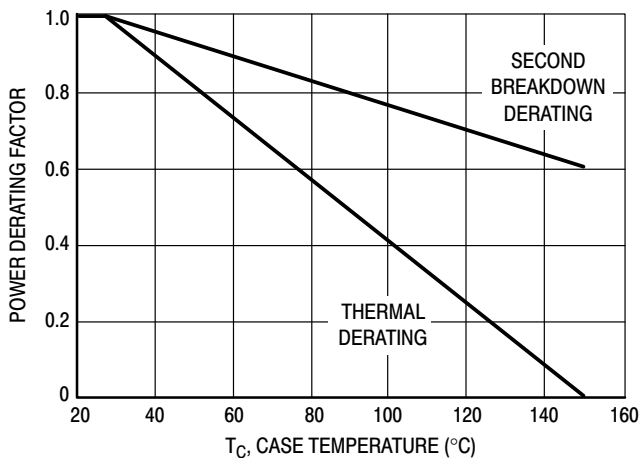


Figure 17. Forward Bias Power Derating

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 Figure 15 is based on $T_C = 25^\circ\text{C}$; $T_J(\text{pk})$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when $T_C \geq 25^\circ\text{C}$. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 15 may be found at any case temperature by using the appropriate curve on Figure 17. $T_J(\text{pk})$ may be calculated from the data in Figures 20 and 21. At any case temperatures, thermal limitations will reduce the power that can be handled to values less the limitations imposed by second breakdown. For inductive loads, high voltage and current must be sustained simultaneously during turn-off with the base-to-emitter junction reverse biased. The safe level is specified as a reverse-biased safe operating area (Figure 16). This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode.

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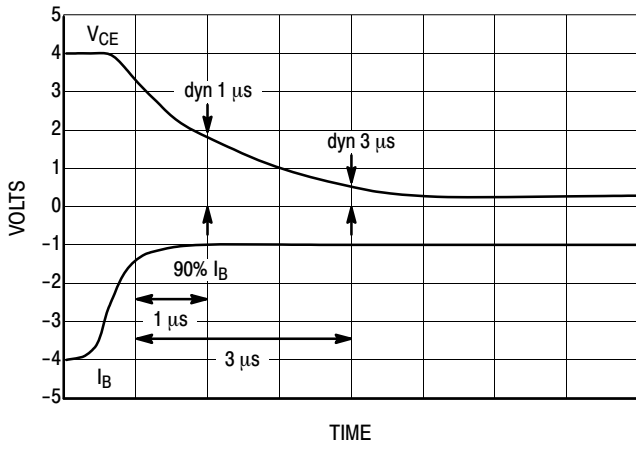


Figure 18. Dynamic Saturation Voltage Measurements

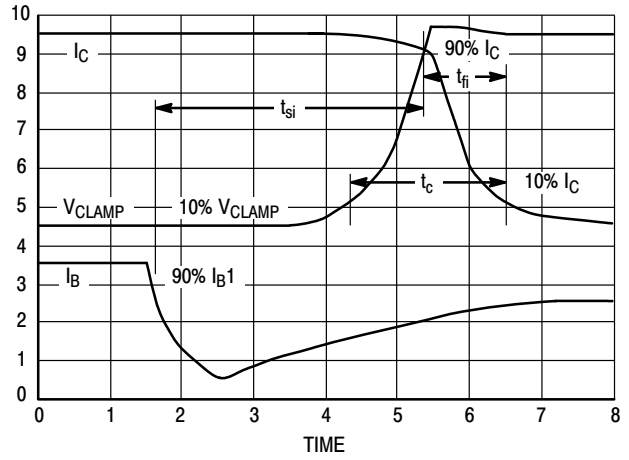
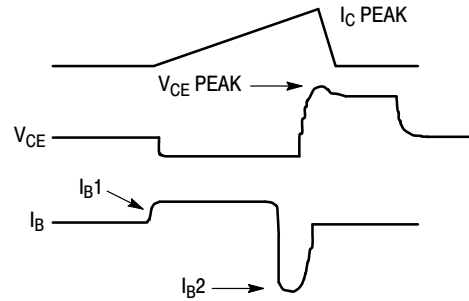
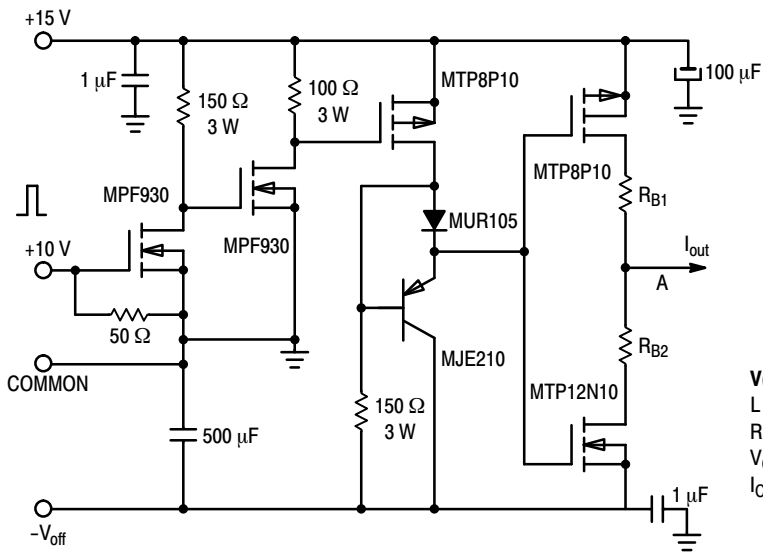


Figure 19. Inductive Switching Measurements



| V(BR)CEO(sus) | INDUCTIVE SWITCHING | RBSOA |
|-----------------|------------------------------|------------------------------|
| L = 10 mH | L = 200 μH | L = 500 μH |
| RB2 = ∞ | RB2 = 0 | RB2 = 0 |
| VCC = 20 VOLTS | VCC = 15 VOLTS | VCC = 15 VOLTS |
| IC(pk) = 100 mA | RB1 SELECTED FOR DESIRED IB1 | RB1 SELECTED FOR DESIRED IB1 |

Table 1. Inductive Load Switching Drive Circuit

MJE18004, MJF18004

TYPICAL THERMAL RESPONSE

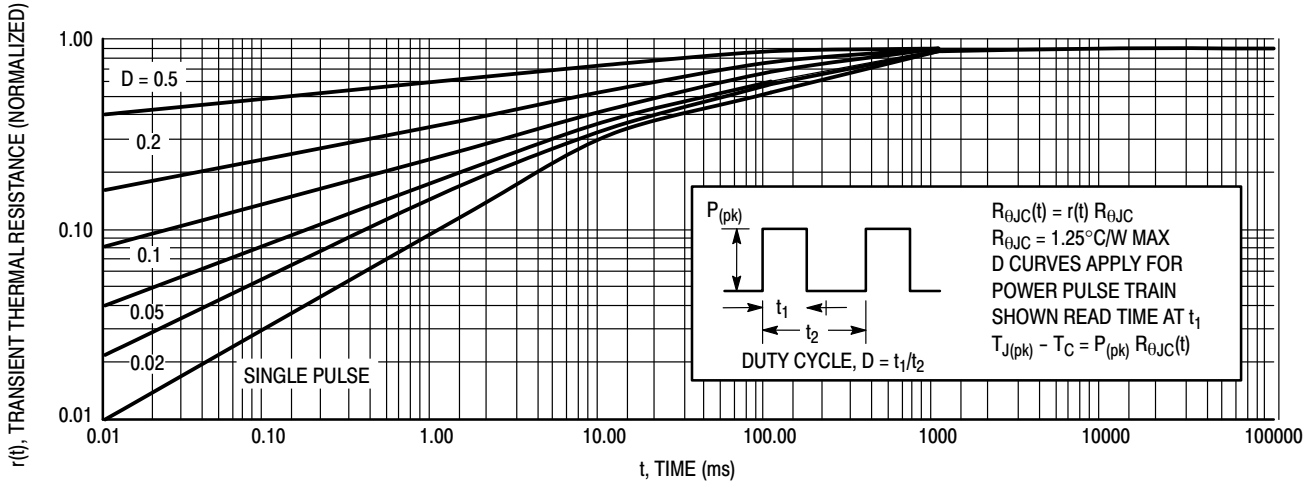


Figure 20. Typical Thermal Response ($Z_{\theta JC}(t)$) for MJE18004

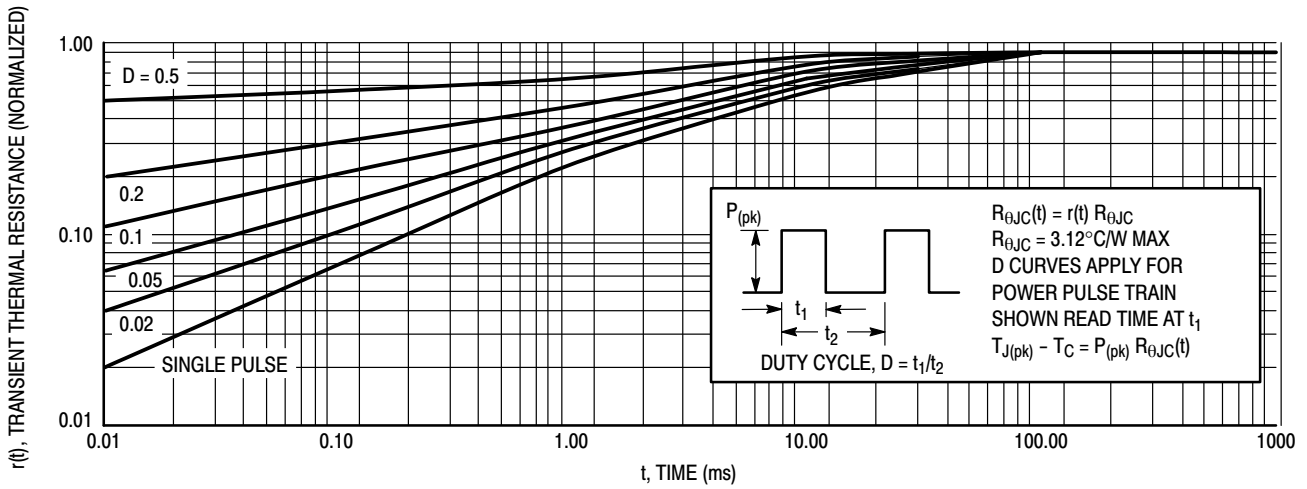


Figure 21. Typical Thermal Response for MJF18004

ORDERING INFORMATION

| Device | Package | Shipping |
|-----------|--------------------------------|-----------------|
| MJE18004G | TO-220AB (Pb-Free) | 50 Units / Rail |
| MJF18004G | TO-220 (Fullpack) (Pb-Free) | 50 Units / Rail |

TEST CONDITIONS FOR ISOLATION TESTS*

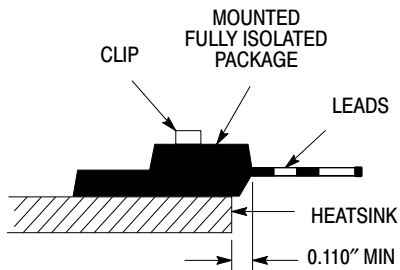


Figure 22a. Screw or Clip Mounting Position for Isolation Test Number 1

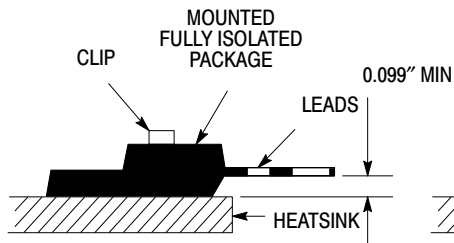


Figure 22b. Clip Mounting Position for Isolation Test Number 2

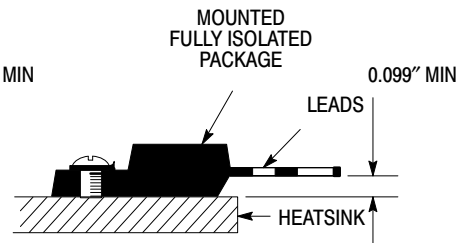


Figure 22c. Screw Mounting Position for Isolation Test Number 3

*Measurement made between leads and heatsink with all leads shorted together

MOUNTING INFORMATION**

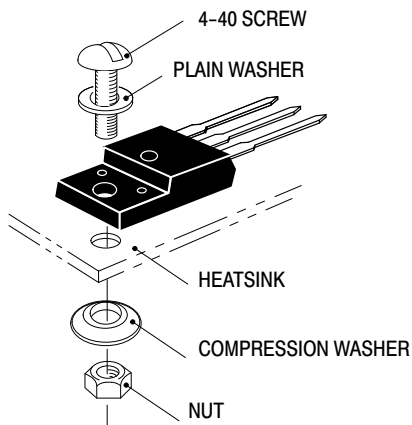


Figure 23a. Screw-Mounted

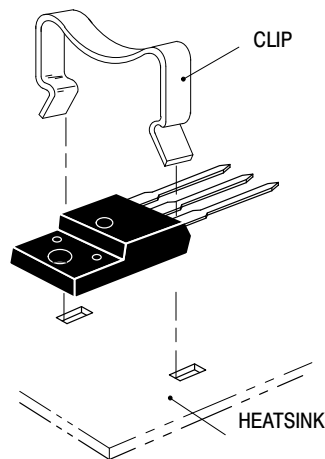


Figure 23b. Clip-Mounted

Figure 23. Typical Mounting Techniques for Isolated Package

Laboratory tests on a limited number of samples indicate, when using the screw and compression washer mounting technique, a screw torque of 6 to 8 in · lbs is sufficient to provide maximum power dissipation capability. The compression washer helps to maintain a constant pressure on the package over time and during large temperature excursions.

Destructive laboratory tests show that using a hex head 4–40 screw, without washers, and applying a torque in excess of 20 in · lbs will cause the plastic to crack around the mounting hole, resulting in a loss of isolation capability.

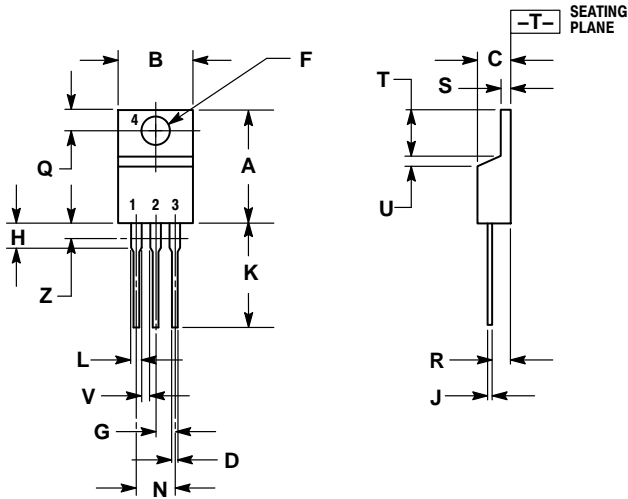
Additional tests on slotted 4–40 screws indicate that the screw slot fails between 15 to 20 in · lbs without adversely affecting the package. However, in order to positively ensure the package integrity of the fully isolated device, ON Semiconductor does not recommend exceeding 10 in · lbs of mounting torque under any mounting conditions.

** For more information about mounting power semiconductors see Application Note AN1040.

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PACKAGE DIMENSIONS

TO-220
CASE 221A-09
ISSUE AH



NOTES:

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

| DIM | INCHES | | MILLIMETERS | |
|-----|--------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.570 | 0.620 | 14.48 | 15.75 |
| B | 0.380 | 0.415 | 9.66 | 10.53 |
| C | 0.160 | 0.190 | 4.07 | 4.83 |
| D | 0.025 | 0.038 | 0.64 | 0.96 |
| F | 0.142 | 0.161 | 3.61 | 4.09 |
| G | 0.095 | 0.105 | 2.42 | 2.66 |
| H | 0.110 | 0.161 | 2.80 | 4.10 |
| J | 0.014 | 0.024 | 0.36 | 0.61 |
| K | 0.500 | 0.562 | 12.70 | 14.27 |
| L | 0.045 | 0.060 | 1.15 | 1.52 |
| N | 0.190 | 0.210 | 4.83 | 5.33 |
| Q | 0.100 | 0.120 | 2.54 | 3.04 |
| R | 0.080 | 0.110 | 2.04 | 2.79 |
| S | 0.045 | 0.055 | 1.15 | 1.39 |
| T | 0.235 | 0.255 | 5.97 | 6.47 |
| U | 0.000 | 0.050 | 0.00 | 1.27 |
| V | 0.045 | --- | 1.15 | --- |
| Z | --- | 0.080 | --- | 2.04 |

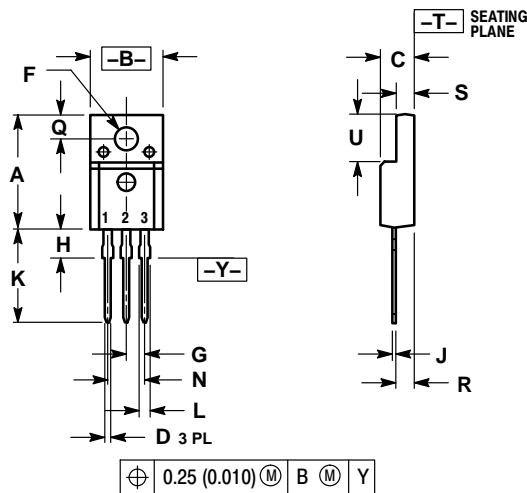
STYLE 1:

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

MJE18004, MJF18004

PACKAGE DIMENSIONS

TO-220 FULLPAK CASE 221D-03 ISSUE K



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH
3. 221D-01 THRU 221D-02 OBSOLETE, NEW STANDARD 221D-03.

| DIM | INCHES | | MILLIMETERS | |
|-----|-----------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 0.617 | 0.635 | 15.67 | 16.12 |
| B | 0.392 | 0.419 | 9.96 | 10.63 |
| C | 0.177 | 0.193 | 4.50 | 4.90 |
| D | 0.024 | 0.039 | 0.60 | 1.00 |
| F | 0.116 | 0.129 | 2.95 | 3.28 |
| G | 0.100 BSC | | 2.54 BSC | |
| H | 0.118 | 0.135 | 3.00 | 3.43 |
| J | 0.018 | 0.025 | 0.45 | 0.63 |
| K | 0.503 | 0.541 | 12.78 | 13.73 |
| L | 0.048 | 0.058 | 1.23 | 1.47 |
| N | 0.200 BSC | | 5.08 BSC | |
| Q | 0.122 | 0.138 | 3.10 | 3.50 |
| R | 0.099 | 0.117 | 2.51 | 2.96 |
| S | 0.092 | 0.113 | 2.34 | 2.87 |
| U | 0.239 | 0.271 | 6.06 | 6.88 |

STYLE 2:

1. BASE
2. COLLECTOR
3. EMITTER

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