



MJE13005-K

NPN SILICON TRANSISTOR

NPN SILICON POWER TRANSISTORS

■ DESCRIPTION

These devices are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V SWITCHMODE.

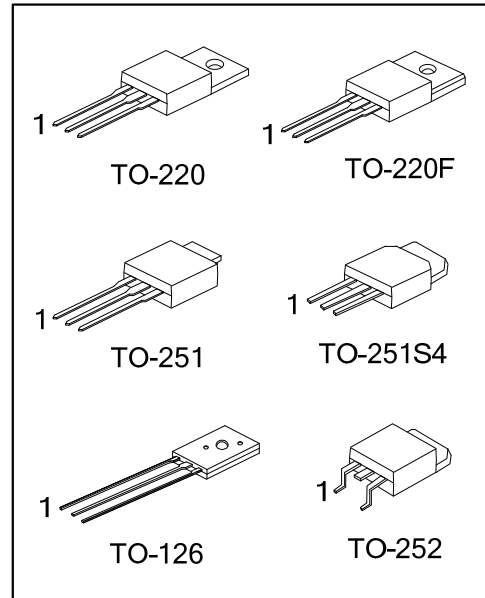
■ FEATURES

- * $V_{CE0(SUS)} = 400\text{ V}$
- * Reverse bias SOA with inductive loads @ $T_C = 100^\circ\text{C}$
- * Inductive switching matrix 2 to 4 Amp, 25 and 100°C
 $t_c @ 3\text{A}, 100^\circ\text{C}$ is 180 ns (Typ)
- * 700V blocking capability
- * SOA and switching applications information

■ APPLICATIONS

- * Switching regulator's, inverters
- * Motor controls
- * Solenoid/Relay drivers
- * Deflection circuits

■ ORDERING INFORMATION



| Ordering Number | | Package | Pin Assignment | | | Packing |
|----------------------|----------------------|----------|----------------|---|---|-----------|
| Lead Free | Halogen Free | | 1 | 2 | 3 | |
| MJE13005L-K-x-TA3-T | MJE13005G-K-x-TA3-T | TO-220 | B | C | E | Tube |
| MJE13005L-K-x-TF3-T | MJE13005G-K-x-TF3-T | TO-220F | B | C | E | Tube |
| MJE13005L-K-x-TM3-T | MJE13005G-K-x-TM3-T | TO-251 | B | C | E | Tube |
| MJE13005L-K-x-TMS4-T | MJE13005G-K-x-TMS4-T | TO-251S4 | B | C | E | Tube |
| MJE13005L-K-x-TN3-R | MJE13005G-K-x-TN3-R | TO-252 | B | C | E | Tape Reel |
| MJE13005L-K-x-T60-R | MJE13005G-K-x-T60-K | TO-126 | B | C | E | Bulk |

Note: Pin Assignment: B: Base C: Collector E: Emitter

| | |
|----------------------------|---|
| <p>MJE13005L-K-x-TA3-T</p> | <p>(1)T: Tube, R: Tape Reel, K: Bulk (2) TA3: TO-220, TF3: TO-220F, TM3: TO-251, TMS4: TO-251S4, TN3: TO-252, T60: TO-126 (3) x: refer to Classification of h_{FE1} (4) L: Lead Free, G: Halogen Free and Lead Free</p> |
|----------------------------|---|

■ MARKING

| TO-220 / TO-220F / TO-251 TO-251S4 / TO-252 | TO-126 |
|--|--------|
| | |

■ ABSOLUTE MAXIMUM RATINGS

| PARAMETER | | SYMBOL | RATINGS | UNIT |
|---|-----------------|----------------|------------|----------------------|
| Collector-Emitter Voltage | | $V_{CEO(SUS)}$ | 400 | V |
| Collector-Emitter Voltage ($V_{BE}=0$) | | V_{CES} | 700 | V |
| Collector-Base Voltage | | V_{CBO} | 700 | V |
| Emitter Base Voltage | | V_{EBO} | 9 | V |
| Collector Current | Continuous | I_C | 4 | A |
| | Peak (1) | I_{CM} | 8 | A |
| Base Current | Continuous | I_B | 2 | A |
| | Peak (1) | I_{BM} | 4 | A |
| Emitter Current | Continuous | I_E | 6 | A |
| | Peak (1) | I_{EM} | 12 | A |
| Power Dissipation at $T_C=25^\circ\text{C}$ | TO-220 | P_D | 75 | W |
| | TO-220F | | 40 | |
| | TO-251/TO-251S4 | | 50 | |
| | TO-252 | | | |
| | TO-126 | | 20 | |
| Derate above 25°C | TO-220 | | 600 | mW/ $^\circ\text{C}$ |
| | TO-220F | | 320 | |
| | TO-251/TO-251S4 | | 400 | |
| | TO-252 | | | |
| | TO-126 | | 160 | |
| Operating and Storage Junction Temperature | | T_J, T_{STG} | -65 ~ +150 | $^\circ\text{C}$ |

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged.

Absolute maximum ratings are stress ratings only and functional device operation is not implied.

■ THERMAL DATA

| PARAMETER | | SYMBOL | RATINGS | UNIT |
|---------------------|-----------------|---------------|---------|---------------------------|
| Junction to Ambient | TO-220/TO-220F | θ_{JA} | 62.5 | $^\circ\text{C}/\text{W}$ |
| | TO-251/TO-251S4 | | 80 | |
| | TO-252 | | | |
| | TO-126 | | 89 | |
| Junction to Case | TO-220 | θ_{JC} | 1.67 | $^\circ\text{C}/\text{W}$ |
| | TO-220F | | 3.125 | |
| | TO-251/TO-251S4 | | 2.5 | |
| | TO-252 | | | |
| | TO-126 | | 6.25 | |

■ ELECTRICAL CHARACTERISTICS (T_C=25°C, unless otherwise specified)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|-----------------------|---|-----|-------|-------------|------|
| OFF CHARACTERISTICS (Note 1) | | | | | | |
| Collector-Emitter Sustaining Voltage | V _{CEO(SUS)} | I _C =10mA, I _B =0 | 400 | | | V |
| Collector Cutoff Current | I _{CBO} | V _{CB0} =Rated Value, V _{BE(OFF)} =1.5V | | | 1 | mA |
| | | V _{CB0} =Rated Value, V _{BE(OFF)} =1.5V, T _C =100°C | | | 5 | |
| Emitter Cutoff Current | I _{EBO} | V _{EB} =9V, I _C =0 | | | 1 | mA |
| SECOND BREAKDOWN | | | | | | |
| Second Breakdown Collector Current with base forward biased | I _{S/B} | | | | See Fig. 11 | |
| Clamped Inductive SOA with Base Reverse Biased | RBSOA | | | | See Fig. 12 | |
| ON CHARACTERISTICS (Note 1) | | | | | | |
| DC Current Gain | h _{FE1} | I _C =0.5A, V _{CE} =5V | 15 | | 50 | |
| | h _{FE2} | I _C =1A, V _{CE} =5V | 10 | | 60 | |
| | h _{FE3} | I _C =2A, V _{CE} =5V | 8 | | 40 | |
| Collector-Emitter Saturation Voltage | V _{CE(SAT)} | I _C =1A, I _B =0.2A | | | 0.5 | V |
| | | I _C =2A, I _B =0.5A | | | 0.6 | V |
| | | I _C =4A, I _B =1A | | | 1 | V |
| | | I _C =2A, I _B =0.5A, T _a =100°C | | | 1 | V |
| Base-Emitter Saturation Voltage | V _{BE(SAT)} | I _C =1A, I _B =0.2A | | | 1.2 | V |
| | | I _C =2A, I _B =0.5A | | | 1.6 | V |
| | | I _C =2A, I _B =0.5A, T _C =100°C | | | 1.5 | V |
| DYNAMIC CHARACTERISTICS | | | | | | |
| Current-Gain-Bandwidth Product | f _T | I _C =500mA, V _{CE} =10V, f=1MHz | 4 | | | MHz |
| Output Capacitance | C _{OB} | V _{CB} =10V, I _E =0, f=0.1MHz | | 65 | | pF |
| SWITCHING CHARACTERISTICS | | | | | | |
| Resistive Load (Table 1) | | | | | | |
| Delay Time | t _D | V _{CC} =125V, I _C =2A, I _{B1} =I _{B2} =0.4A, t _p =25μs, Duty Cycle≤1% | | 0.025 | 0.1 | μs |
| Rise Time | t _R | | | 0.3 | 0.7 | μs |
| Storage Time | t _S | | | 1.7 | 4 | μs |
| Fall Time | t _F | | | 0.4 | 0.9 | μs |

Note: 1. Pulse Test: Pulse Width=5ms, Duty Cycle≤10%

2. Pulse Test: P_W=300μs, Duty Cycle≤2%

■ CLASSIFICATION OF h_{FE1}

| RANK | A | B | C | D | E |
|-------|---------|---------|---------|---------|---------|
| RANGE | 15 ~ 20 | 20 ~ 25 | 25 ~ 30 | 30 ~ 40 | 40 ~ 50 |

APPLICATION INFORMATION

Table 1. Test Conditions for Dynamic Performance

| Reverse Bias Safe Operating Area and Inductive Switching | | Resistive Switching |
|--|--|--|
| Test Circuits | <p>DUTY CYCLE $\leq 10\%$ $t_r, t_f \leq 10\text{ns}$</p> <p>Note: Pw and Vcc Adjusted for Desired I_c R_B Adjusted for Desired I_{B1}</p> | <p>*SELECTED FOR $\geq 1\text{kV}$</p> |
| Circuit Values | <p>Coil Data : $V_{CC}=20\text{V}$ FERROXCUBE core #6656 Full Bobbin (~ 16 Turns) #16</p> <p>GAP for 200$\mu\text{H}/20\text{ A}$ $L_{\text{COIL}}=200\mu\text{H}$ $V_{\text{CLAMP}}=300\text{V}$</p> | <p>$V_{CC}=125\text{V}$ $R_C=62\Omega$ $D1=1\text{n}5820$ or Equiv. $R_B=22\Omega$</p> |
| Test Waveforms | <p>OUTPUT WAVEFORMS</p> <p>t_1 Adjusted to Obtain I_c $t_1 = \frac{L_{\text{COIL}}(I_{\text{CPK}})}{V_{CC}}$ $t_2 = \frac{L_{\text{COIL}}(I_{\text{CPK}})}{V_{\text{CLAMP}}}$</p> <p>Test Equipment Scope-Tektronics 475 or Equivalent</p> | <p>$t_r, t_f < 10\text{ns}$ Duty Cycle = 1.0% R_B and R_C adjusted for desired I_b and I_c</p> |

RESISTIVE SWITCHING PERFORMANCE

Fig. 1 Turn-On Time

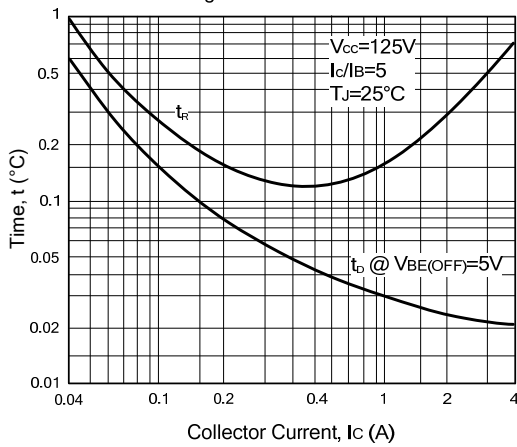


Fig. 2 Turn-Off Time

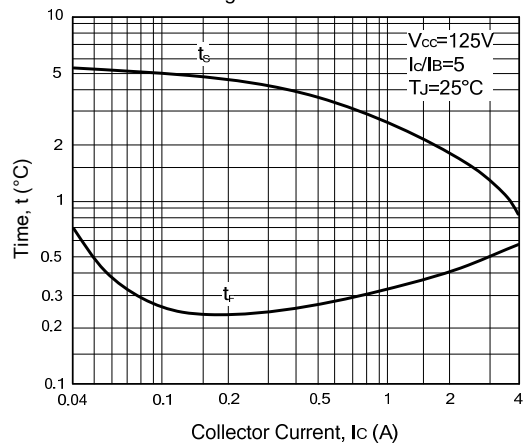


Fig. 3 Typical Thermal Response [$Z_{\theta JC}(t)$]

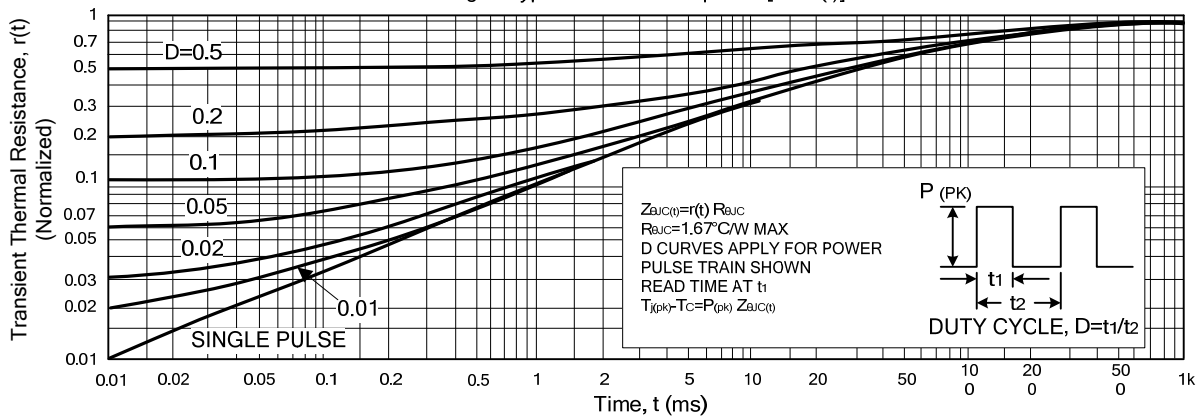


Fig. 4 Forward Bias Safe Operating Area

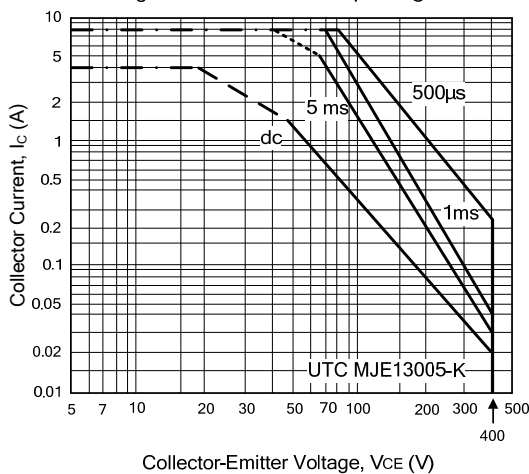
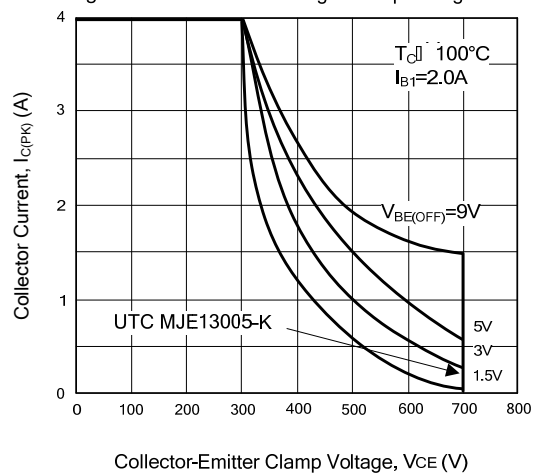
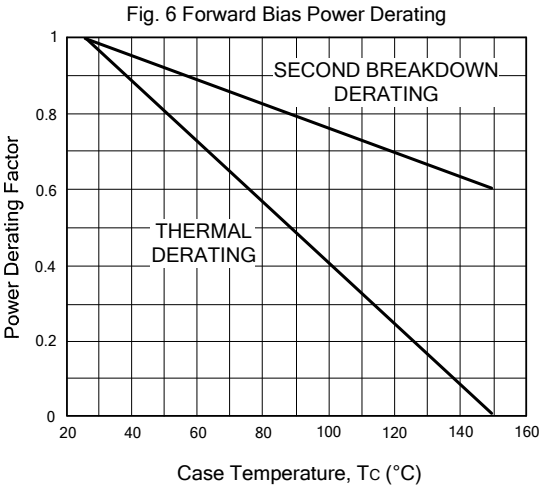


Fig. 5 Reverse Bias Switching Safe Operating Area



■ RESISTIVE SWITCHING PERFORMANCE (Cont.)



■ SAFE OPERATING AREA INFORMATION

FORWARD BIAS

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; e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Fig. 4 is based on $T_C = 25^\circ\text{C}$; $T_{J(PK)}$ 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 Fig. 4 may be found at any case temperature by using the appropriate curve on Fig. 6.

$T_{J(PK)}$ may be calculated from the data in Fig. 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

REVERSE BIAS

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 5 gives the complete RBSOA characteristics.

TYPICAL CHARACTERISTICS

Figure 7. DC Current Gain

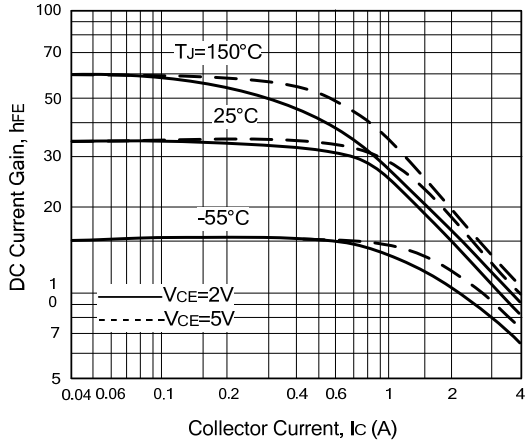


Figure 8. Collector Saturation Region

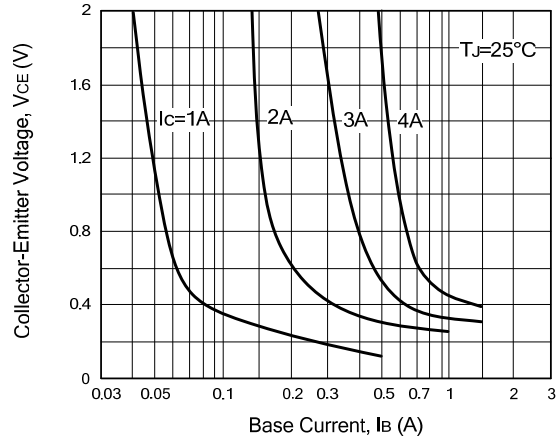


Figure 9. Base-Emitter Voltage

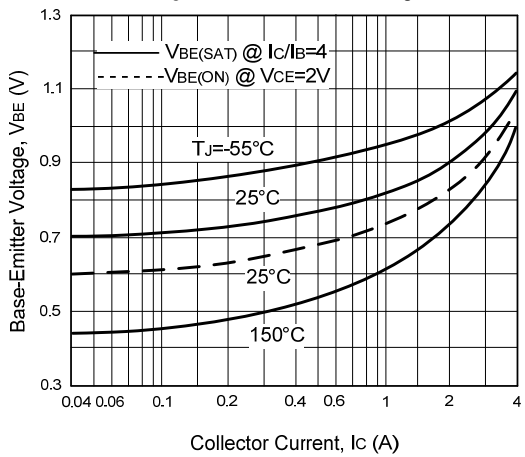


Figure 10. Collector-Emitter Saturation Voltage

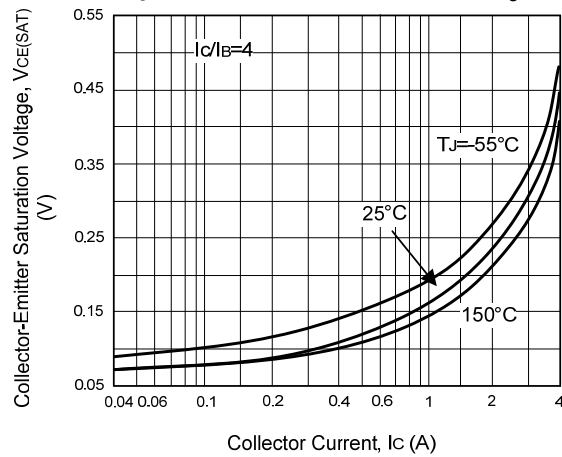


Figure 11. Collector Cutoff Region

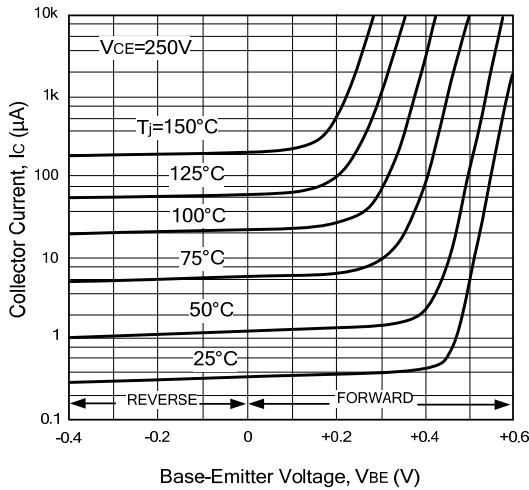
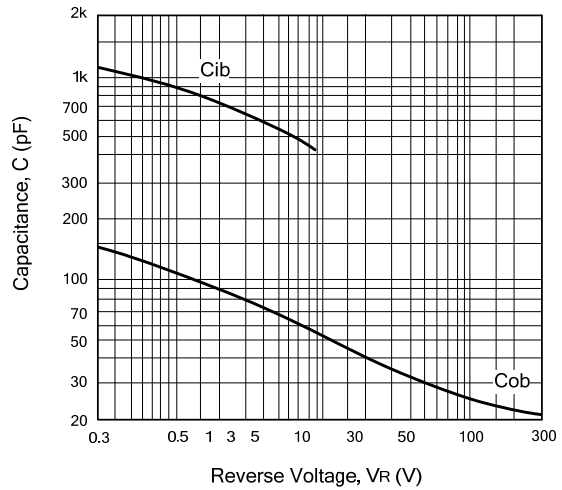


Figure 12. Capacitance



UTC assumes no responsibility for equipment failures that result from using products at values that exceed, even momentarily, rated values (such as maximum ratings, operating condition ranges, or other parameters) listed in products specifications of any and all UTC products described or contained herein. UTC products are not designed for use in life support appliances, devices or systems where malfunction of these products can be reasonably expected to result in personal injury. Reproduction in whole or in part is prohibited without the prior written consent of the copyright owner. The information presented in this document does not form part of any quotation or contract, is believed to be accurate and reliable and may be changed without notice.