$V_{CE}$ = 650 V, $I_C$ = 40 A
Trench Field Stop IGBTs with Fast Recovery Diode

# KGF65A4H, MGF65A4H, FGF65A4H

Data Sheet

## Description

The KGF65A4H, MGF65A4H, and FGF65A4H are 650 V Field Stop IGBTs. Sanken original trench structure decreases gate capacitance, and achieves high speed switching and switching loss reduction. Thus, these Field Stop IGBTs can improve the efficiency of your circuit.

## Features

- Low Saturation Voltage
- High Speed Switching
- With Integrated Fast Recovery Diode
- RoHS Compliant

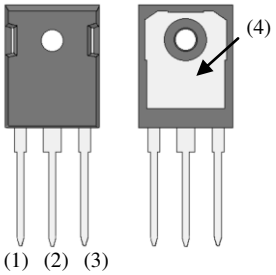
- $V_{CE}$ ---------- 650 V
- $I_C$ ($T_C$ = 100 °C) ---------- 40 A
- Short Circuit Withstand Time ---------- 10 µs
- $V_{CE(sat)}$ ---------- 1.9 V typ.
- $t_f$ ($T_J$ = 175 °C) ---------- 60 ns typ.
- $V_F$ ---------- 1.8 V typ.

## Applications

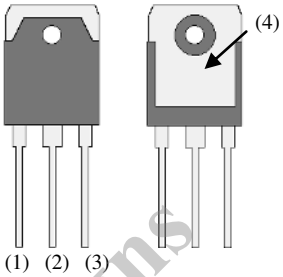
- Welding Converters
- PFC Circuit

## Packages

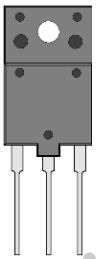
TO247-3L

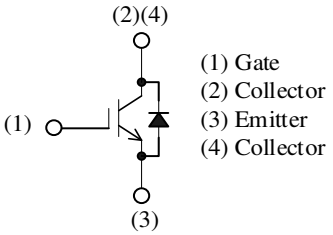



TO3P-3L




TO3PF-3L




Not to scale

## Selection Guide

| Part Number | Package |
|---|---|
| KGF65A4H | TO247-3L |
| MGF65A4H | TO3P-3L |
| FGF65A4H | TO3PF-3L |

## Absolute Maximum Ratings

Unless otherwise specified, $T_A$ = 25 °C

| Parameter | Symbol | Conditions | Rating | Unit | Remarks |
|---|---|---|---|---|---|
| Collector to Emitter Voltage | $V_{CE}$ | | 650 | V | |
| Gate to Emitter Voltage | $V_{GE}$ | | ±30 | V | |
| Continuous Collector Current [1] | $I_C$ | $T_C$ = 25 °C | 65 | A | |
| | | $T_C$ = 100 °C | 40 | A | |
| Pulsed Collector Current | $I_{C(PULSE)}$ | PW ≤ 1 ms, duty cycle ≤ 1% | 120 | A | |
| Diode Continuous Forward Current [1] | $I_F$ | $T_C$ = 25 °C | 40[2] | A | |
| | | $T_C$ = 100 °C | 30 | A | |
| Diode Pulsed Forward Current | $I_{F(PULSE)}$ | PW ≤ 1 ms, duty cycle ≤ 1% | 100 | A | |
| Short Circuit Withstand Time | $t_{SC}$ | $V_{GE}$ = 15 V, $V_{CE}$ = 400 V, $T_J$ = 175 °C | 10 | µs | |
| Power Dissipation | $P_D$ | $T_C$ = 25 °C | 288 | W | MGF65A4H KGF65A4H |
| | | | 72 | | FGF65A4H |
| Operating Junction Temperature | $T_J$ | | 175 | °C | |
| Storage Temperature | $T_{STG}$ | | −55 to 150 | °C | |
| Isolation Voltage | $V_{ISO(RMS)}$ | Between surface of case and all pins that are shorted; AC, 60 Hz, 1 min | 1500 | V | FGF65A4H |

## Thermal Characteristics

Unless otherwise specified, $T_A$ = 25 °C

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| Thermal Resistance of IGBT (Junction to Case) | $R_{\theta JC}$ (IGBT) | | — | — | 0.52 | °C/W | MGF65A4H KGF65A4H |
| | | | — | — | 2.08 | | FGF65A4H |
| Thermal Resistance of Diode (Junction to Case) | $R_{\theta JC}$ (Di) | | — | — | 1.15 | °C/W | MGF65A4H KGF65A4H |
| | | | — | — | 2.28 | | FGF65A4H |



[1] $I_C$ and $I_F$ are determined by the maximum junction temperature for TO3P-3L package.
[2] Determined by bonding wires capability.

## Electrical Characteristics

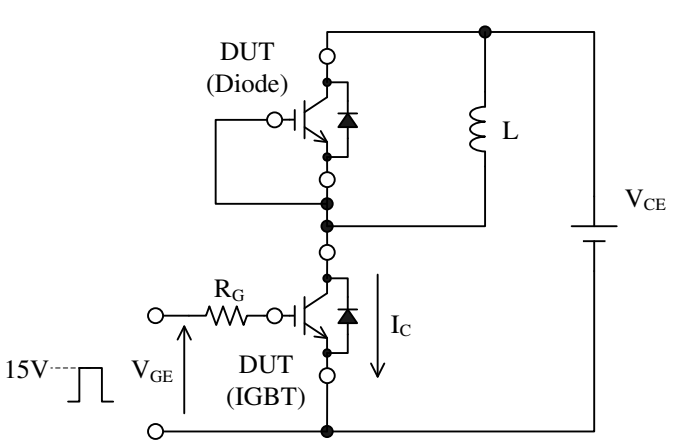
Unless otherwise specified, $T_A$ = 25 °C

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Collector to Emitter Breakdown Voltage | $V_{(BR)CES}$ | $I_C$ = 100 µA, $V_{GE}$ = 0 V | 650 | — | — | V |
| Collector to Emitter Leakage Current | $I_{CES}$ | $V_{CE}$ = 650 V, $V_{GE}$ = 0 V | — | — | 100 | µA |
| Gate to Emitter Leakage Current | $I_{GES}$ | $V_{GE}$ = ±30 V | — | — | ±500 | nA |
| Gate Threshold Voltage | $V_{GE(TH)}$ | $V_{CE}$ = 10 V, $I_C$ = 1 mA | 4.0 | 5.5 | 7.0 | V |
| Collector to Emitter Saturation Voltage | $V_{CE(sat)}$ | $V_{GE}$ = 15 V, $I_C$ = 40 A | — | 1.9 | 2.37 | V |
| Input Capacitance | $C_{ies}$ | $V_{CE}$ = 20 V, $V_{GE}$ = 0 V, f = 1.0 MHz | — | 2300 | — | pF |
| Output Capacitance | $C_{oes}$ | | — | 250 | — | |
| Reverse Transfer Capacitance | $C_{res}$ | | — | 110 | — | |
| Gate Charge | $Q_g$ | $V_{CE}$ = 520 V, $I_C$ = 40 A, $V_{GE}$ = 15 V | — | 75 | — | nC |
| Turn-on Delay Time | $t_{d(on)}$ | $T_J$ = 25 °C, see Figure 1 | — | 40 | — | ns |
| Rise Time | $t_r$ | | — | 40 | — | |
| Turn-off Delay Time | $t_{d(off)}$ | | — | 100 | — | |
| Fall Time | $t_f$ | | — | 40 | — | |
| Turn-on Energy (3) | $E_{on}$ | | — | 0.7 | — | mJ |
| Turn-off Energy | $E_{off}$ | | — | 0.6 | — | |
| Turn-on Delay Time | $t_{d(on)}$ | $T_J$ = 175 °C, see Figure 1 | — | 40 | — | ns |
| Rise Time | $t_r$ | | — | 40 | — | |
| Turn-off Delay Time | $t_{d(off)}$ | | — | 130 | — | |
| Fall Time | $t_f$ | | — | 60 | — | |
| Turn-on Energy (3) | $E_{on}$ | | — | 1.3 | — | mJ |
| Turn-off Energy | $E_{off}$ | | — | 0.9 | — | |
| Emitter to Collector Diode Forward Voltage | $V_F$ | $I_F$ = 30 A | — | 1.8 | — | V |
| Emitter to Collector Diode Reverse Recovery Time | $t_{rr}$ | $I_F$ = 30 A, di/dt = 700 A/µs | — | 50 | — | ns |



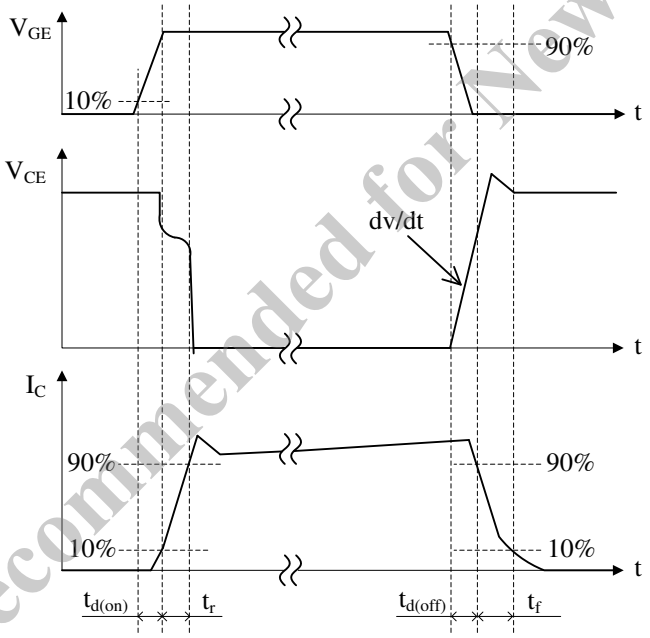
(3) Energy losses include the reverse recovery of diode.

## Test Circuits and Waveforms




Conditions:
$V_{CE}$ = 400 V
$I_C$ = 40 A
$V_{GE}$ = 15 V
$R_G$ = 10 Ω
L = 100 µH

(a) Test Circuit




(b) Waveform

Figure 1. Test Circuits and Waveforms of dv/dt and Switching Time

## Rating and Characteristic Curves

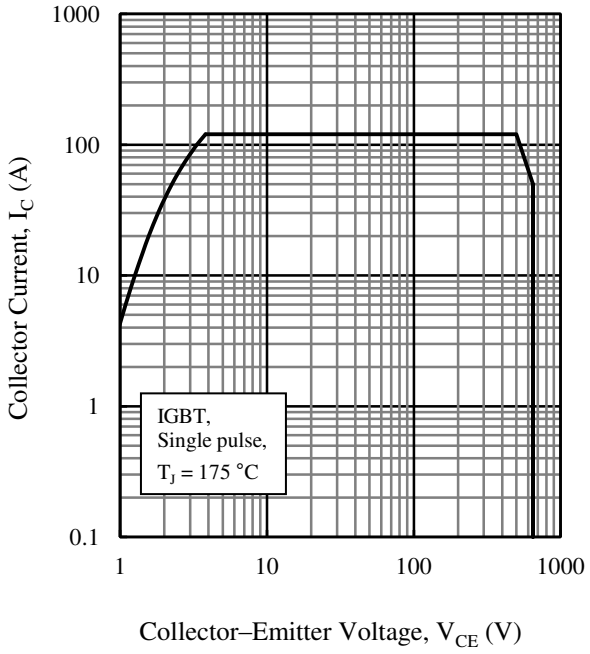



Figure 2. IGBT Reverse Bias Safe Operating Area

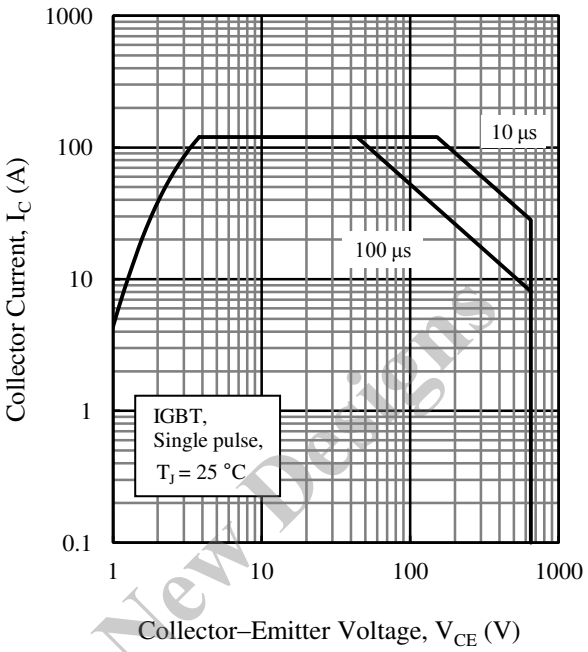



Figure 3. IGBT Safe Operating Area

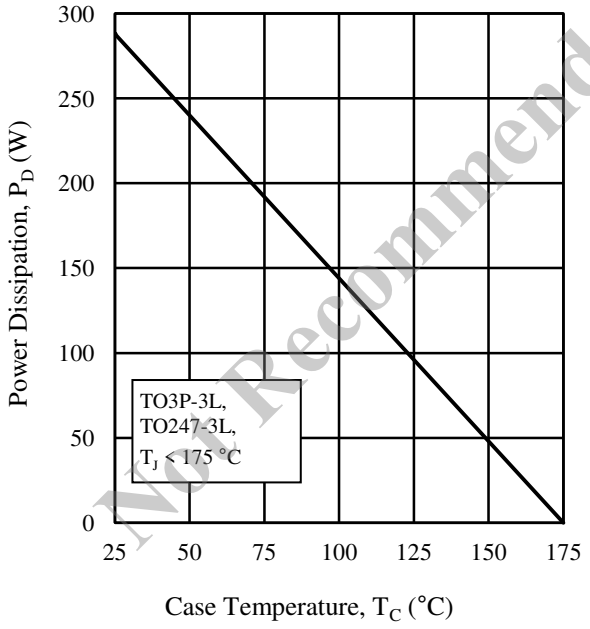



Figure 4. Power Dissipation vs. TO3P-3L and TO247-3L Case Temperature

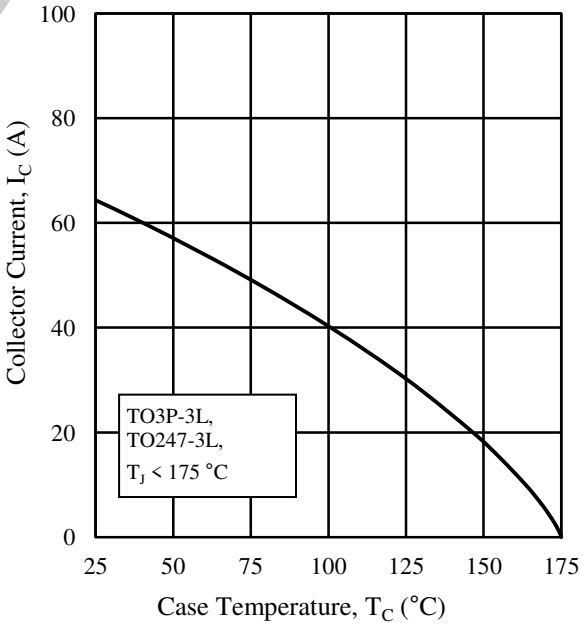



Figure 5. Collector Current vs. TO3P-3L and TO247-3L Case Temperature

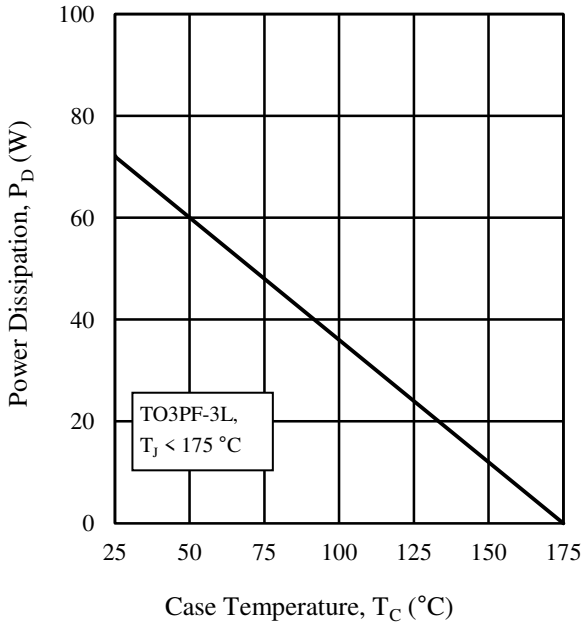



Figure 6. Power Dissipation vs. TO3PF-3L Case Temperature

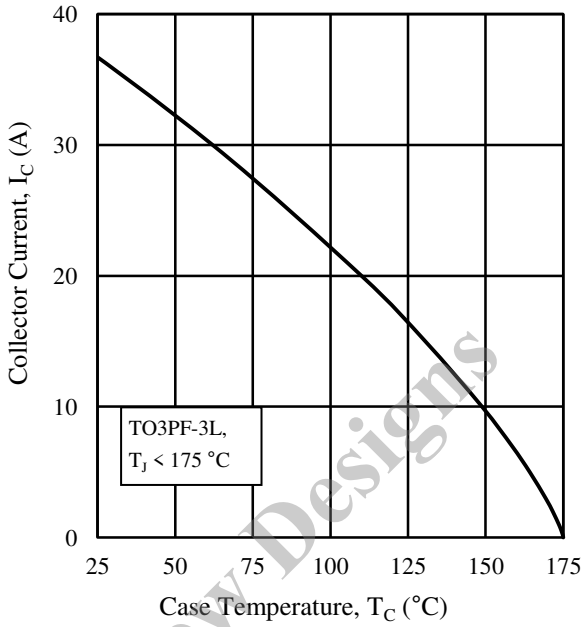



Figure 7. Collector Current vs. TO3PF-3L Case Temperature

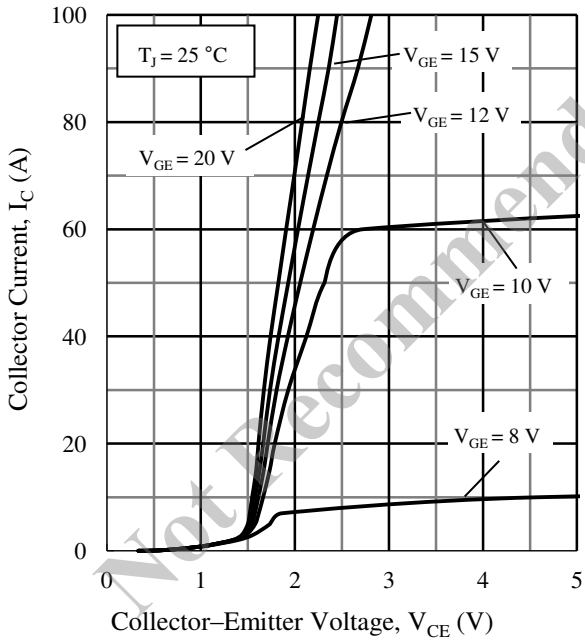



Figure 8. Output Characteristics ($T_J$ = 25 °C)

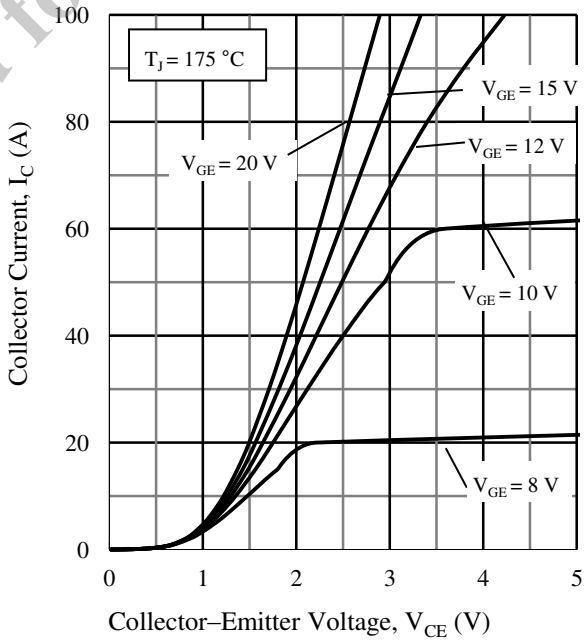



Figure 9. Output Characteristics ($T_J$ = 175 °C)

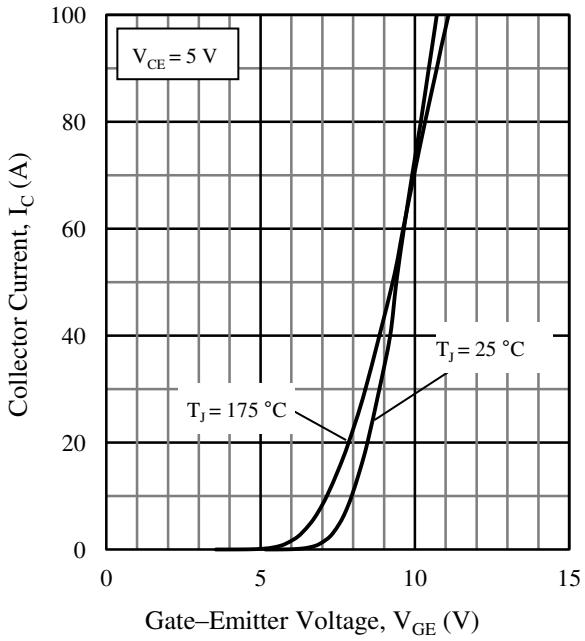



Figure 10. Transfer Characteristics

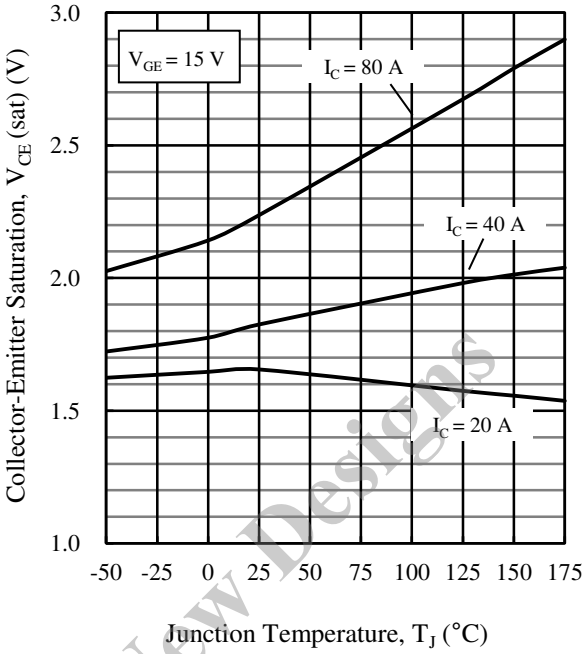



Figure 11. Saturation Voltage vs. Junction Temperature

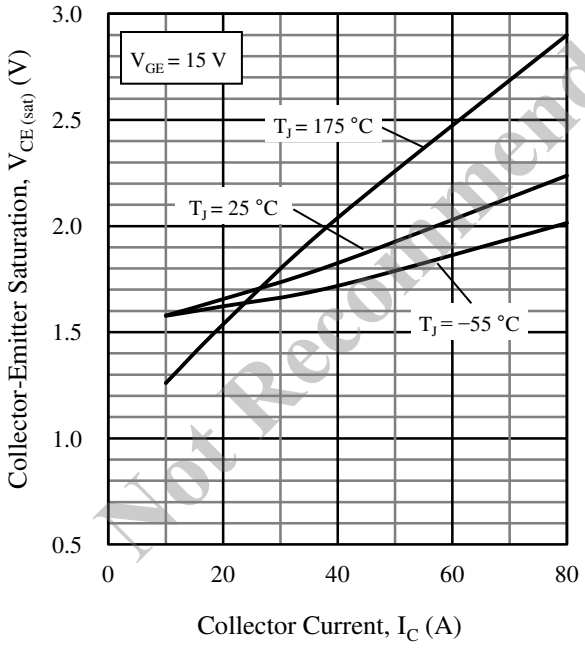



Figure 12. Saturation Voltage vs. Collector Current

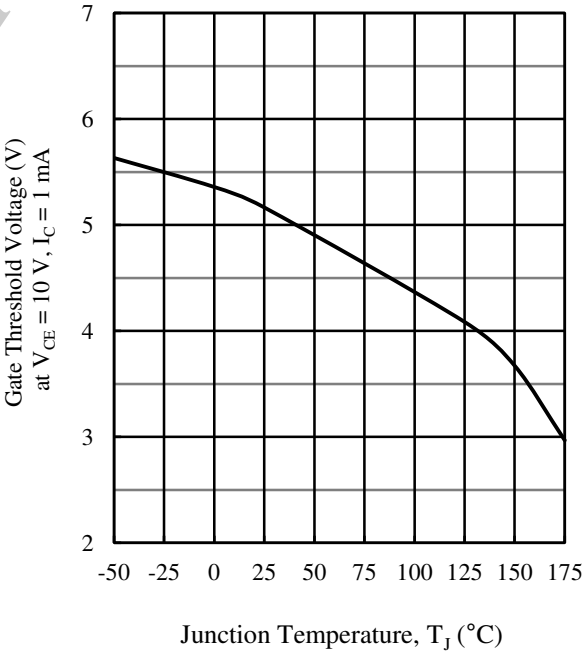



Figure 13. Gate Threshold Voltage vs. Junction Temperature

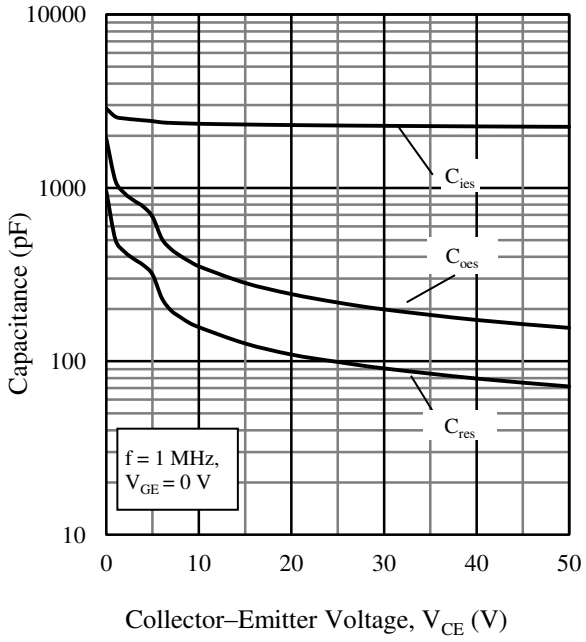



Figure 14. Capacitance Characteristics

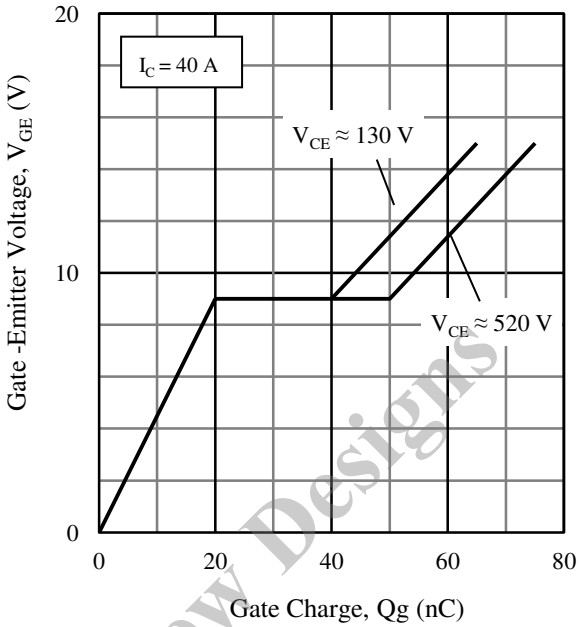



Figure 15. Typical Gate Charge

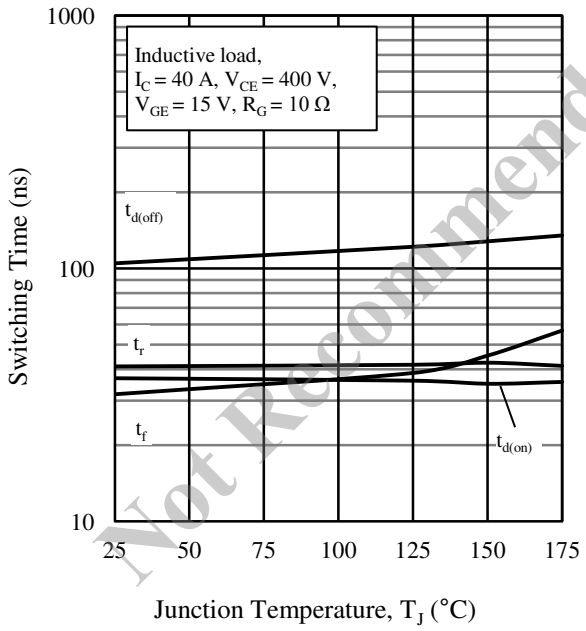



Figure 16. Switching Time vs. Junction Temperature

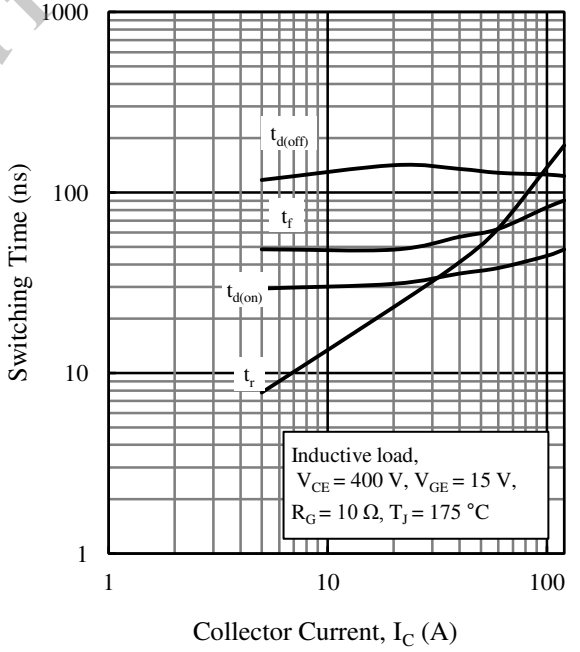



Figure 17. Switching Time vs. Collector Current

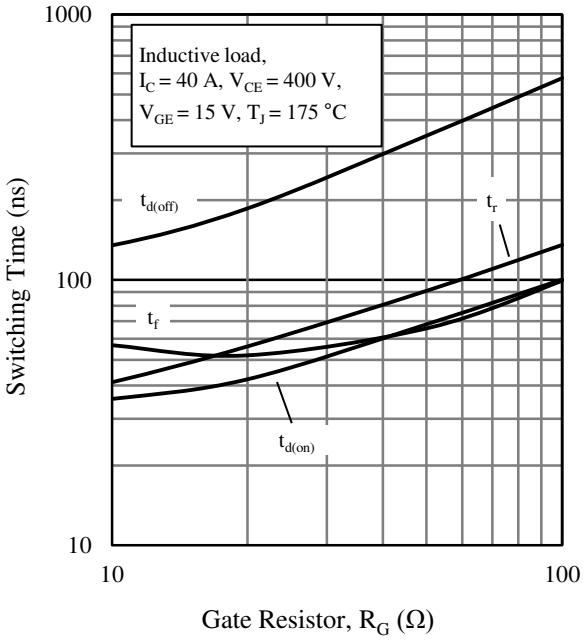



Figure 18. Switching Time vs. Gate Resistor

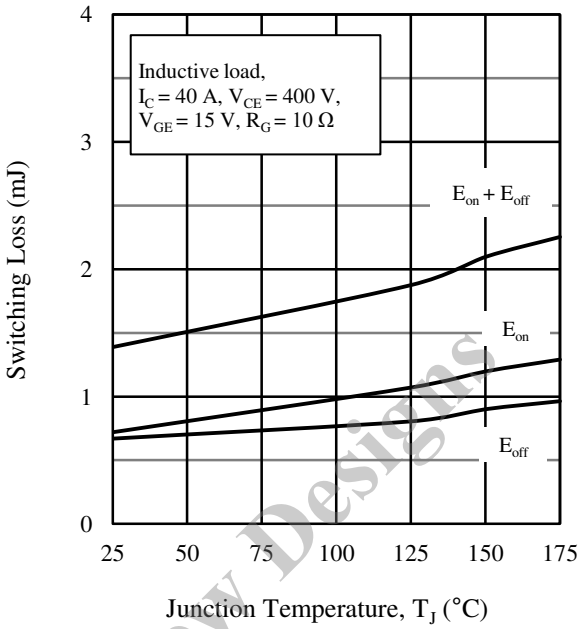



Figure 19. Switching Loss vs. Junction Temperature

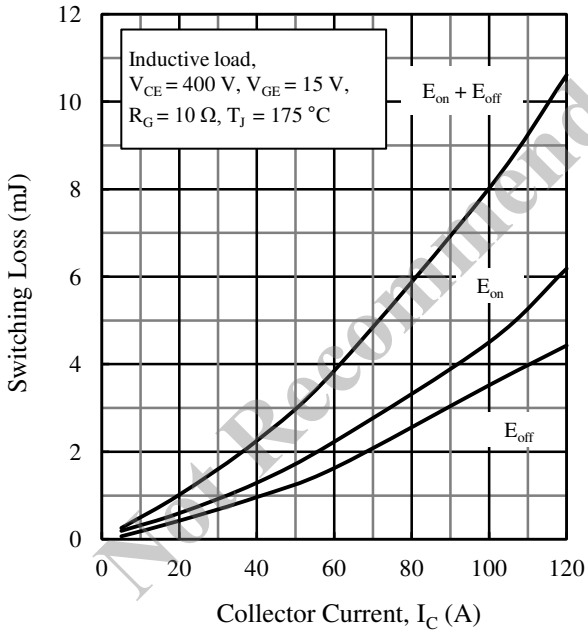



Figure 20. Switching Loss vs. Collector Current

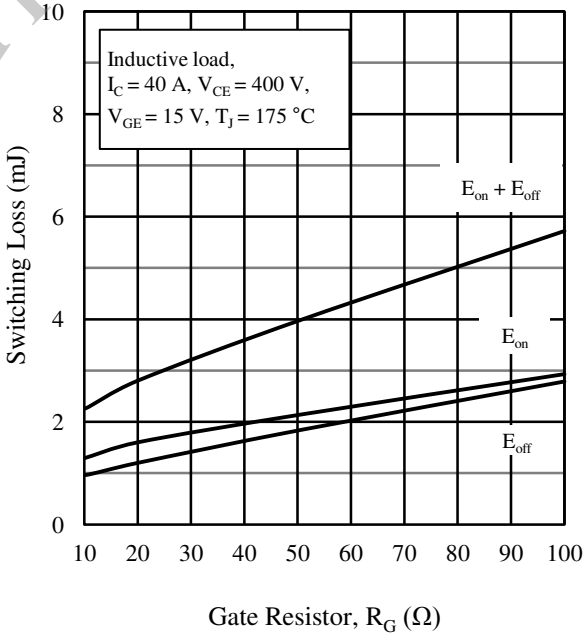



Figure 21. Switching Loss vs. Gate Resistor

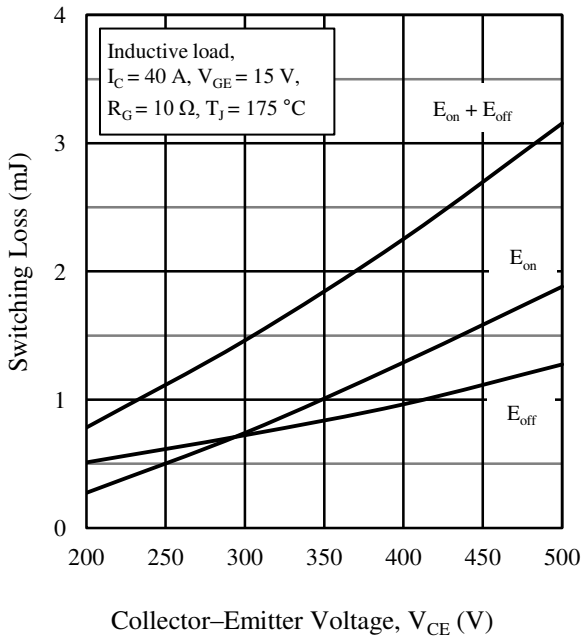



Figure 22. Switching Loss vs. Collector–Emitter Voltage

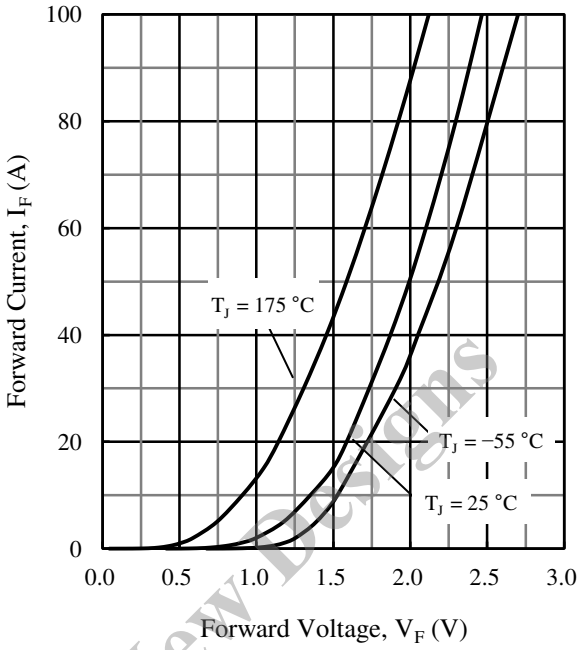



Figure 23. Diode Forward Characteristics

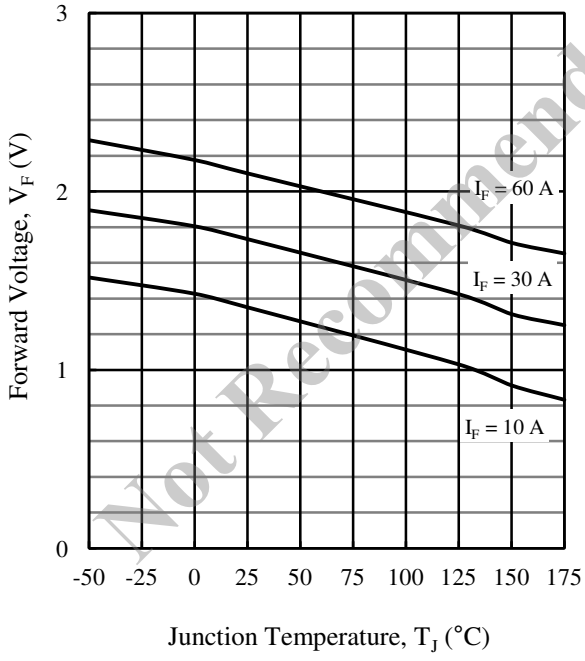



Figure 24. Diode Forward Voltage vs. Junction Temperature

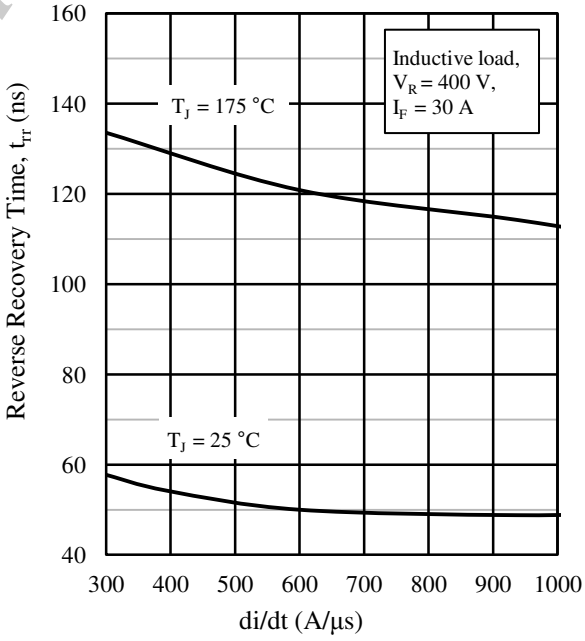



Figure 25. Diode Reverse Recovery Time vs. di/dt

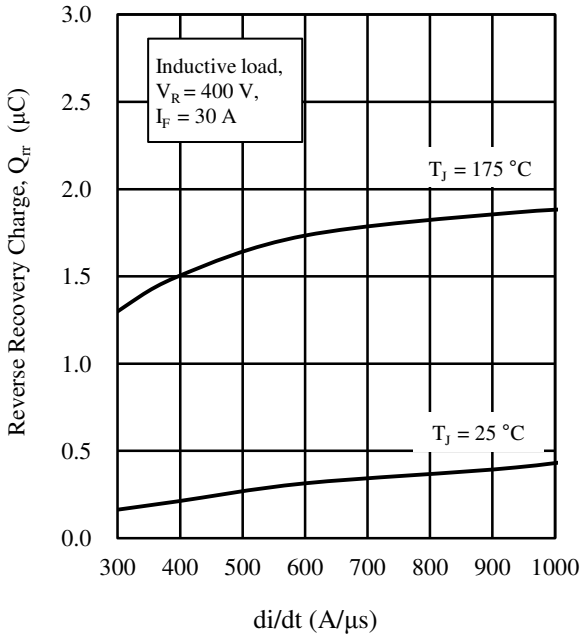



Figure 26. Diode Reverse Recovery Charge vs. di/dt

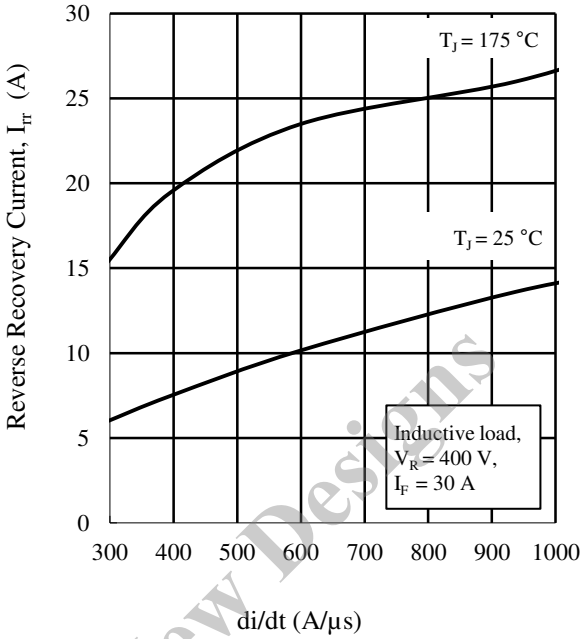



Figure 27. Diode Reverse Recovery Current vs. di/dt

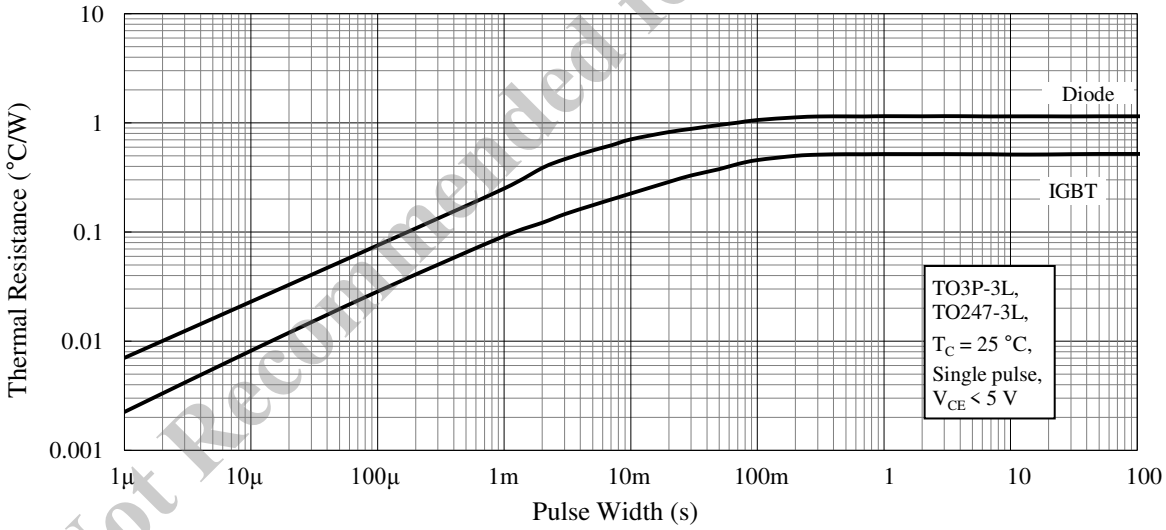



Figure 28. Transient Thermal Resistance (TO3P-3L and TO247-3L)

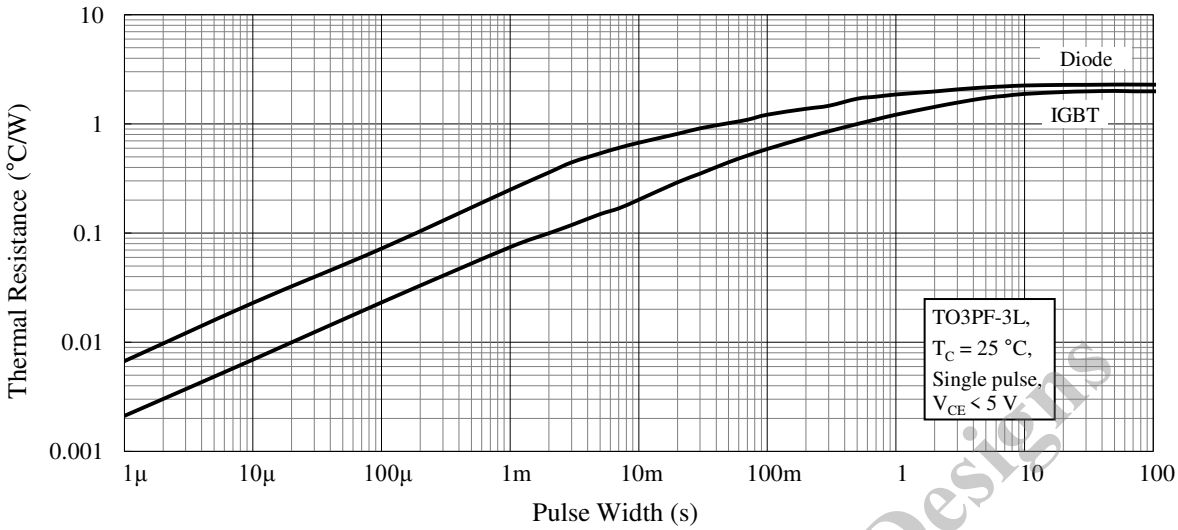
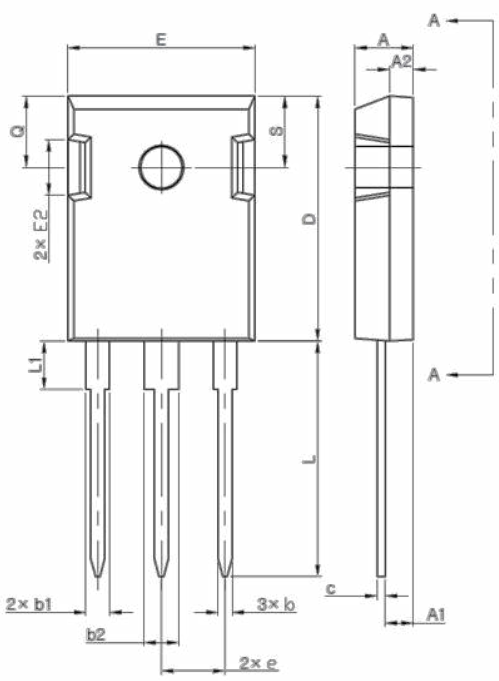



Figure 29. Transient Thermal Resistance (TO3PF-3L)

## Physical Dimensions

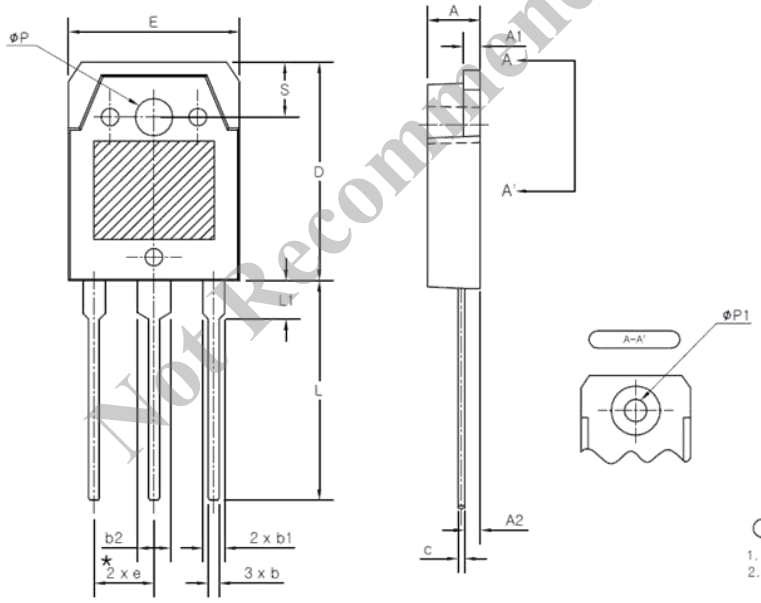
● **TO247-3L**




| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 4.83 | 5.02 | 5.21 |
| A1 | 2.29 | 2.41 | 2.54 |
| A2 | 1.91 | 2.04 | 2.16 |
| b | 1.14 | 1.27 | 1.40 |
| b1 | 1.91 | 2.10 | 2.20 |
| b2 | 2.92 | 3.10 | 3.20 |
| c | 0.61 | 0.71 | 0.80 |
| D | 20.80 | 21.07 | 21.34 |
| D1 | 17.43 | 17.63 | 17.83 |
| E | 15.75 | 15.94 | 16.13 |
| E1 | 13.06 | 13.26 | 13.46 |
| E2 | 4.32 | 4.58 | 4.83 |
| e | 5.25 | 5.45 | 5.65 |
| L | 19.81 | 20.19 | 20.57 |
| L1 | 3.81 | 4.07 | 4.32 |
| ΦP | 3.55 | 3.60 | 3.65 |
| Q | 5.59 | 5.90 | 6.20 |
| S | | 6.15 BSC | |

NOTE
1. THESE DIMENSION DO NOT INCLUDE MOLD PROTRUSION

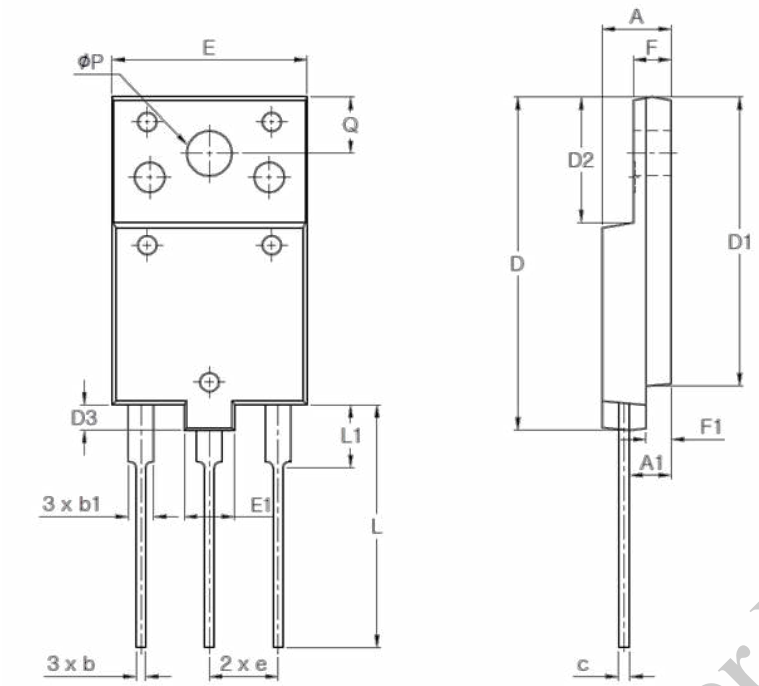
● **TO3P-3L**




| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 4.60 | 4.80 | 5.00 |
| A1 | 1.45 | 1.50 | 1.65 |
| A2 | 1.20 | 1.40 | 1.60 |
| b | 0.80 | 1.00 | 1.20 |
| b1 | 1.80 | 2.00 | 2.20 |
| b2 | 2.80 | 3.00 | 3.20 |
| c | 0.55 | 0.60 | 0.75 |
| D | 19.70 | 19.90 | 20.10 |
| E | 15.40 | 15.60 | 15.80 |
| *e | 5.25 | 5.45 | 5.65 |
| L | 19.80 | 20.00 | 20.20 |
| L1 | 3.30 | 3.50 | 3.70 |
| ΦP | 3.30 | 3.40 | 3.50 |
| ΦP1 | 3.10 | 3.20 | 3.30 |
| S | 4.80 | 5.00 | 5.20 |

NOTE
1. THESE DIMENSIONS DO NOT INCLUDE PROTRUSIONS OF THE MOLD.
2. THE "( )" MARK IS THE REFERENCE

● **TO3PF-3L**



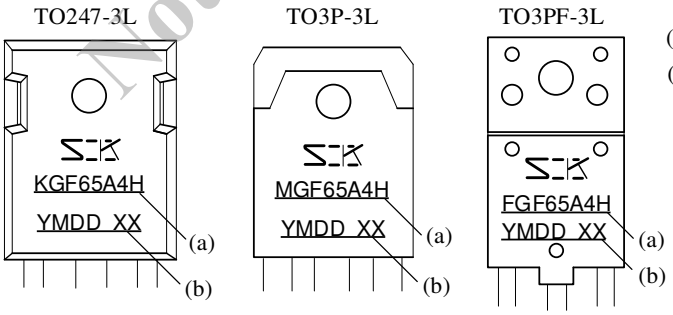

| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 5.30 | 5.50 | 5.70 |
| A1 | 3.10 | 3.30 | 3.50 |
| b | 0.65 | 0.75 | 0.95 |
| b1 | 1.80 | 2.00 | 2.20 |
| c | 0.80 | 0.90 | 1.10 |
| D | 26.30 | 26.50 | 26.70 |
| D1 | 22.80 | 23.00 | 23.20 |
| D2 | 9.80 | 10.00 | 10.20 |
| D3 | 1.80 | 2.00 | 2.20 |
| E | 15.30 | 15.50 | 15.70 |
| E1 | 3.80 | 4.00 | 4.20 |
| e | 5.25 | 5.45 | 5.65 |
| F | 2.80 | 3.00 | 3.20 |
| F1 | 1.80 | 2.00 | 2.20 |
| L | 19.10 | 19.30 | 19.50 |
| L1 | 4.80 | 5.00 | 5.20 |
| Q | 4.30 | 4.50 | 4.70 |
| ØP | 3.40 | 3.60 | 3.80 |

**NOTES:**

- Dimensions in millimeters
- Bare lead frame TO247, TO3P and TO3PF: Pb-free (RoHS compliant)
- When soldering the products, it is required to minimize the working time within the following limits:
  Flow: 260 ± 5 °C / 10 ± 1 s, 2 times
  Soldering Iron: 380 ± 10 °C / 3.5 ± 0.5 s, 1 time (Soldering should be at a distance of at least 1.5 mm from the body of the products.)
- Soldering should be at a distance of at least 1.5 mm from the body of the products.
- The recommended screw torque for TO247, TO3P and TO3PF: 0.686 N·m to 0.882 N·m (7 kgf·cm to 9 kgf·cm)
-



## Marking Diagram




(a) Part Number

(b) Lot Number

Y is the last digit of the year of manufacture (0 to 9).
M is the month of the year (1 to 9, O, N, or D).
DD is the day of the month (01 to 31).
XX is the control number.

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