650 V, 30 A
Trench Field stop IGBTs with Fast Recovery Diode

# KGF65A3H, MGF65A3H, FGF65A3H

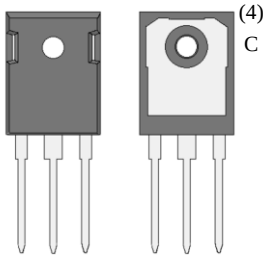
## Features

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

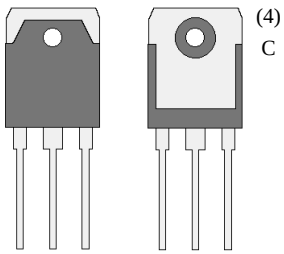
- $V_{CE}$ ---------- 650 V
- $I_C$ ($T_C$ = 100 °C) ---------- 30 A
- Short circuit withstand time ---------- 10 µs
- $V_{CE(sat)}$ ---------- 1.9 V typ.
- $t_f$ ($T_j$ = 175 °C) ---------- 60 ns typ.
- $V_F$ ---------- 1.8 V typ.

## Package (Not to scale)

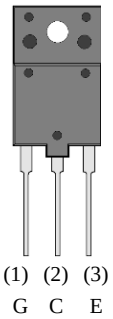
TO247-3L




TO3P-3L



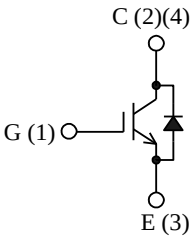

TO3PF-3L




## Applications

- Welding Converters
- Uninterruptible Power Supplies (UPS)
- PFC circuit
- Inverter circuit
- Bridge circuit

## Equivalent circuit




## xGF65A3H Series

| Products | KGF65A3H | MGF65A3H | FGF65A3H |
|---|---|---|---|
| Package | TO247-3L | TO3P-3L | TO3PF-3L |

## Absolute Maximum Ratings

- Unless otherwise specified, $T_A$ = 25 °C

| Parameter | Symbol | Test conditions | Rating | Unit | Notes |
|---|---|---|---|---|---|
| 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 | 50 | A | |
| | | $T_C$= 100 °C | 30 | A | |
| Pulsed Collector Current | $I_{C(PULSE)}$ | PW ≤ 1ms<br>Duty cycle ≤ 1 % | 90 | 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 ≤ 1ms<br>Duty cycle ≤ 1 % | 90 | A | |
| Short Circuit Withstand Time | $t_{SC}$ | $V_{GE}$ = 15 V,<br>$V_{CE}$ = 400 V | 10 | µs | |
| Power Dissipation | $P_D$ | $T_C$ = 25 °C | 217 | W | MGF65A3H<br>KGF65A3H |
| | | | 72 | | FGF65A3H |
| Operating Junction Temperature | $T_J$ | | 175 | °C | |
| Storage Temperature Range | $T_{stg}$ | | − 55 to 150 | °C | |

(1) $I_C$ and $I_F$ are limited by maximum junction temperature of TO3P-3L package.
(2) Limited by bond wire.

## Thermal Characteristics

• Unless otherwise specified, $T_A$ = 25 °C

| Parameter | Symbol | Test Conditions | Min. | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|---|---|
| Thermal Resistance of IGBT (Junction to Case) | $R_{\theta JC}$(IGBT) | | – | – | 0.69 | °C/W | MGF65A3H KGF65A3H |
| | | | – | – | 2.08 | | FGF65A3H |
| Thermal Resistance of Diode (Junction to Case) | $R_{\theta JC}$(Di) | | – | – | 1.15 | °C/W | MGF65A3H KGF65A3H |
| | | | | | 2.28 | | FGF65A3H |

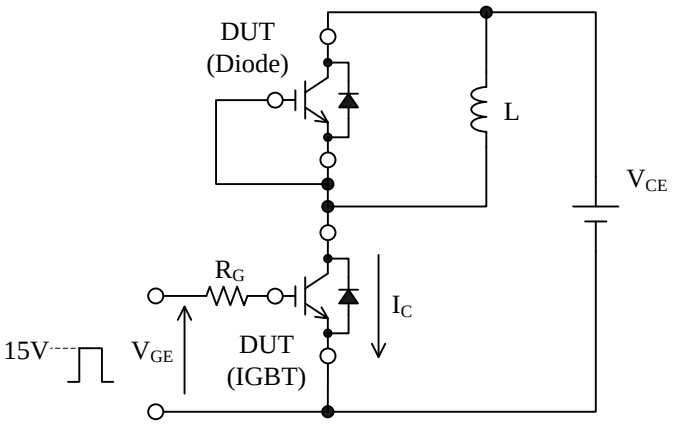
## Electrical Characteristics

• Unless otherwise specified, $T_A$ = 25 °C

| Parameter | Symbol | Test 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, $I_C$ = 30 A | – | 1.9 | 2.4 | V |
| Input Capacitance | $C_{ies}$ | $V_{CE}$ = 20 V<br>$V_{GE}$ = 0 V<br>f = 1.0 MHz | – | 1800 | – | pF |
| Output Capacitance | $C_{oes}$ | | – | 200 | – | |
| Reverse Transfer Capacitance | $C_{res}$ | | – | 80 | – | |
| Gate charge | $Q_g$ | $V_{CE}$ = 520 V, $I_C$ = 30 A<br>$V_{GE}$ = 15 V | – | 60 | – | nC |
| Turn-On Delay Time | $t_{d(on)}$ | $T_j$ = 25 °C<br>Refer to Figure 1 | – | 30 | – | ns |
| Rise Time | $t_r$ | | – | 30 | – | |
| Turn-Off Delay Time | $t_{d(off)}$ | | – | 90 | – | |
| Fall Time | $t_f$ | | – | 30 | – | |
| Turn-on energy* | $E_{on}$ | | – | 0.5 | – | mJ |
| Turn-off energy | $E_{off}$ | | – | 0.4 | – | |
| Turn-On Delay Time | $t_{d(on)}$ | $T_j$ = 175 °C<br>Refer to Figure 1 | – | 30 | – | ns |
| Rise Time | $t_r$ | | – | 30 | – | |
| Turn-Off Delay Time | $t_{d(off)}$ | | – | 120 | – | |
| Fall Time | $t_f$ | | – | 60 | – | |
| Turn-on energy* | $E_{on}$ | | – | 1.0 | – | mJ |
| Turn-off energy | $E_{off}$ | | – | 0.7 | – | |
| 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<br>di/dt = 700 A/µs | – | 50 | – | ns |

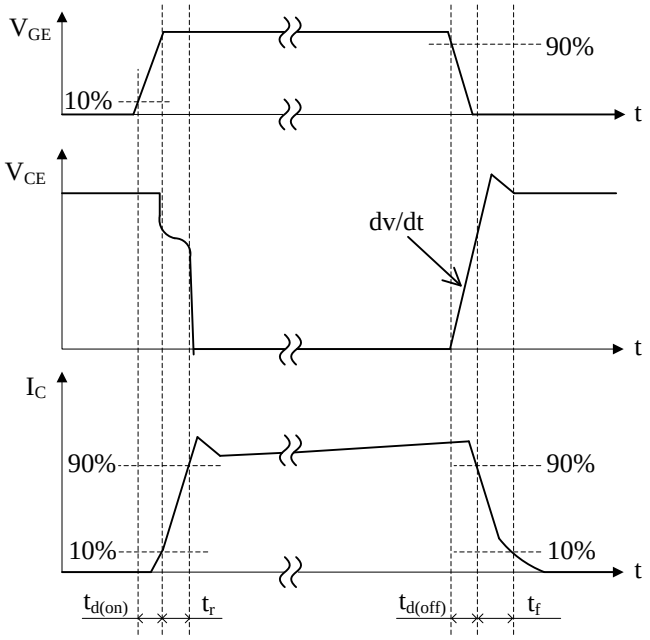
*Energy losses include the reverse recovery of diode.

## Test Circuits and Waveforms




Test conditions
$V_{CE}$ = 400 V
$I_C$ = 30 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

## Typical Characteristic Curves

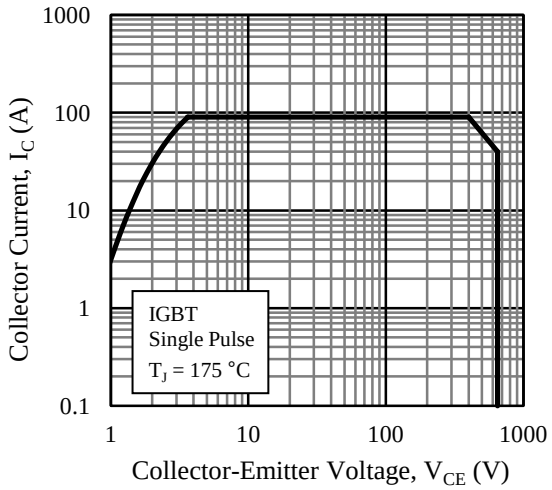



Figure 2. Reverse Bias Safe Operating Area

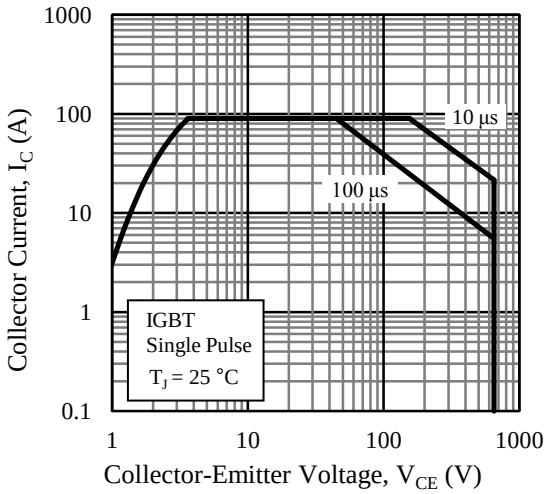



Figure 3. Safe Operating Area

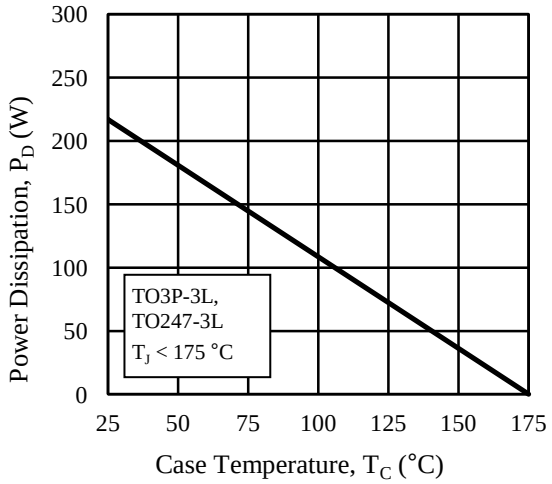



Figure 4. Power Dissipation vs. TO3P and TO247 Case Temperature

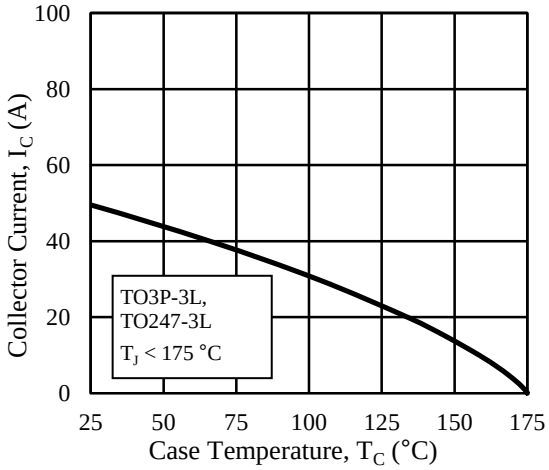



Figure 5. Collector Current vs. TO3P and TO247 Case Temperature

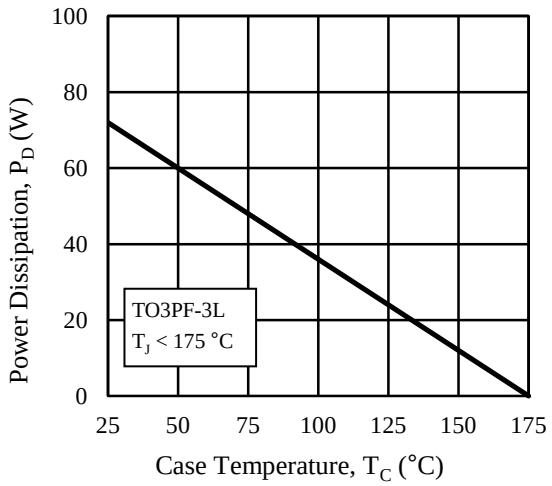



Figure 6. Power Dissipation vs. TO3PF Case Temperature

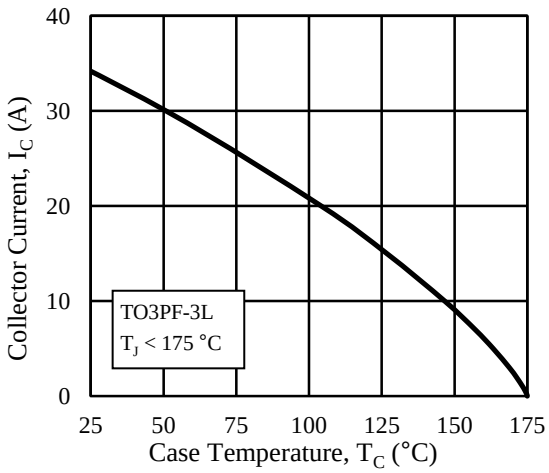



Figure 7. Collector Current vs. TO3PF Case Temperature

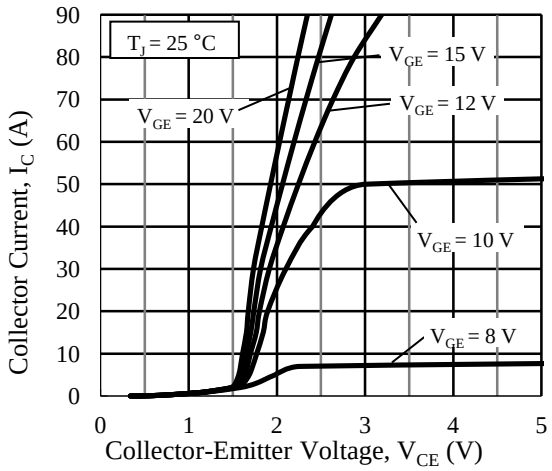



Figure 8. Output Characteristics ($T_J$ = 25 °C)

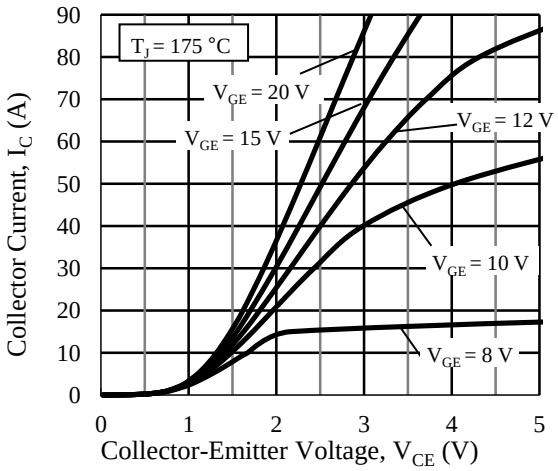



Figure 9. Output Characteristics ($T_J$ = 175 °C)

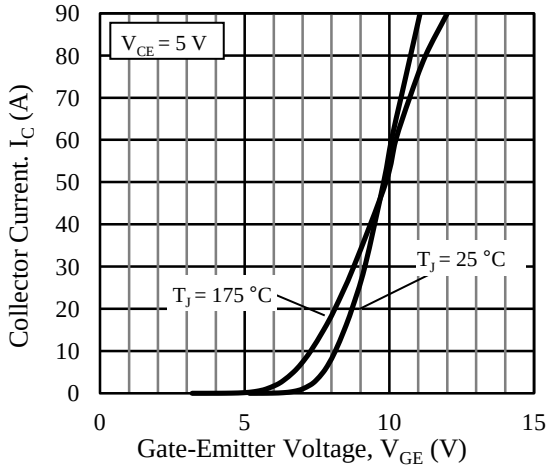



Figure 10. Transfer Characteristics

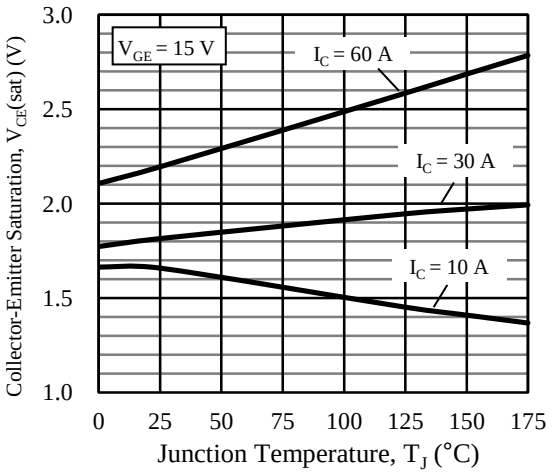



Figure 11. Saturation Voltage vs. Junction Temperature

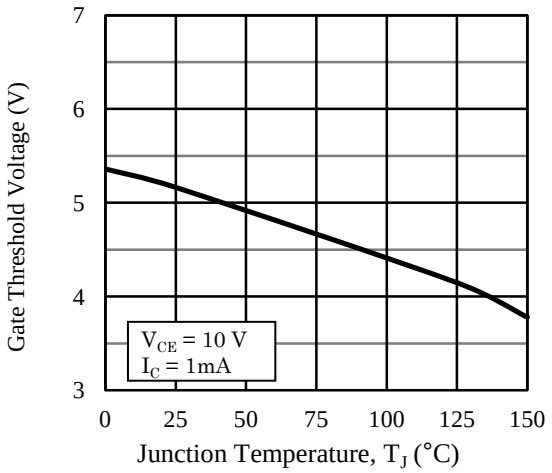



Figure 12. Gate Threshold Voltage vs. Junction Temperature

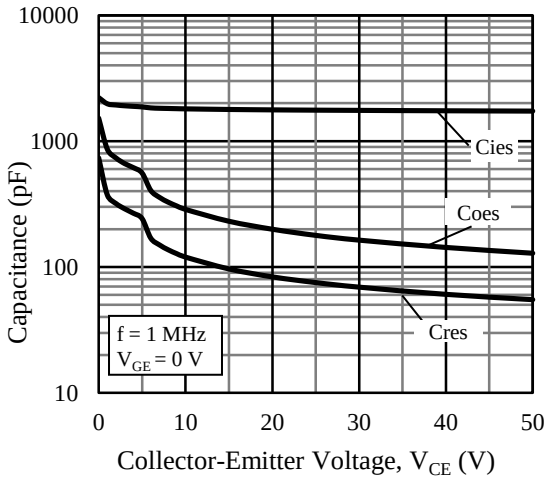



Figure 13. Capacitance Characteristics

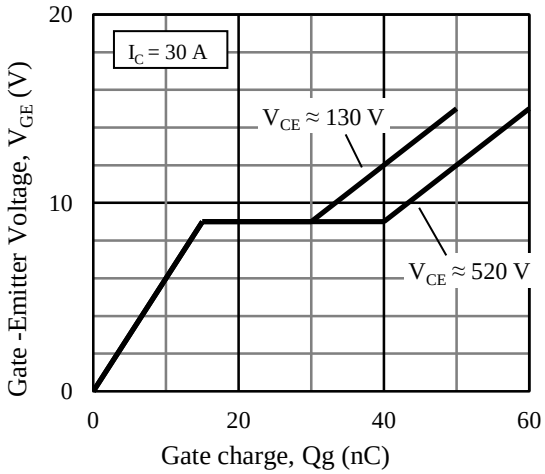



Figure 14. Typical Gate Charge

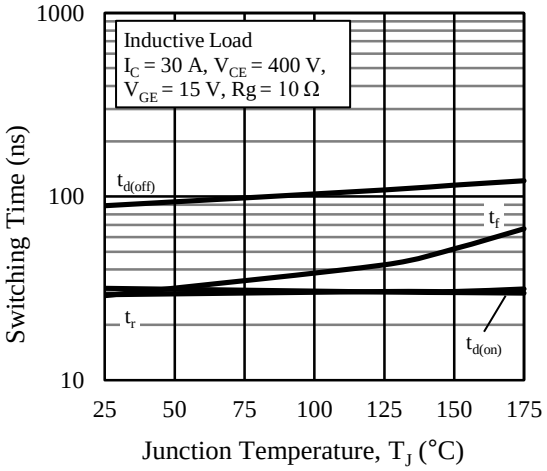



Figure 15. Switching time vs. Junction Temperature

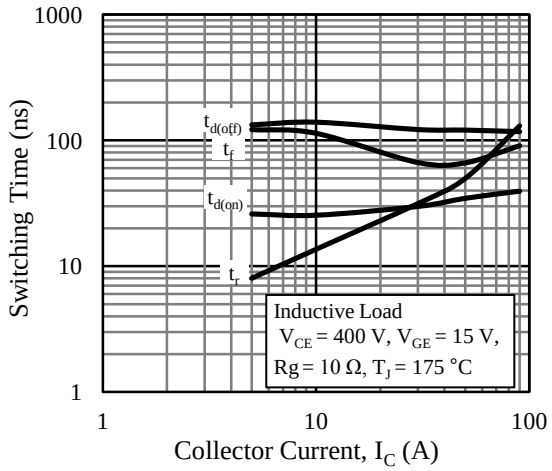



Figure 16. Switching Time vs. Collector Current

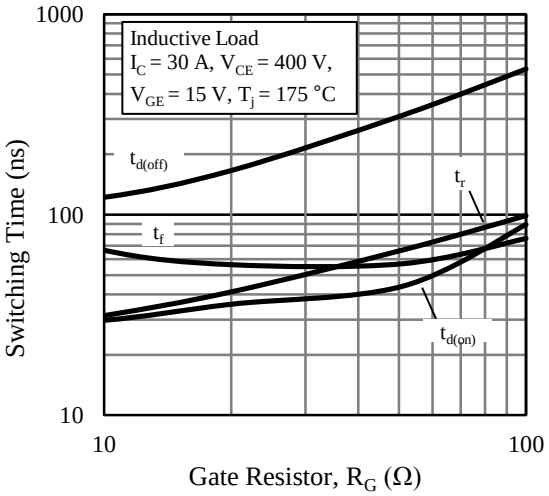



Figure 17. Switching Time vs. Gate Resistor

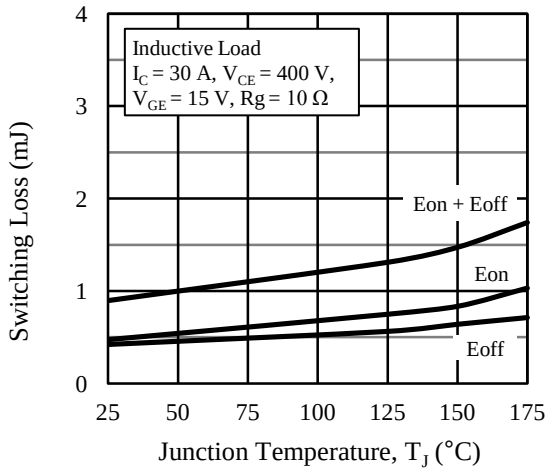



Figure 18. Switching Loss vs. Junction Temperature

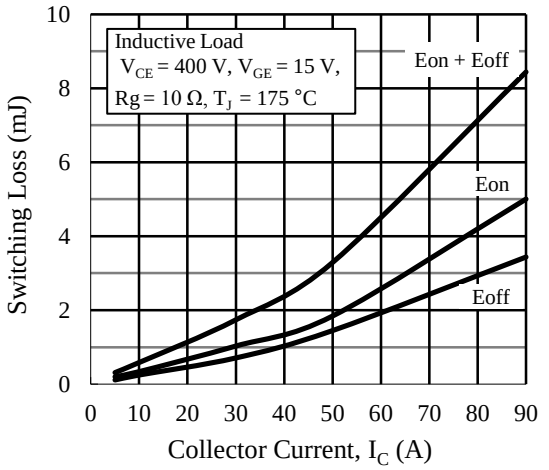



Figure 19. Switching Loss vs. Collector Current

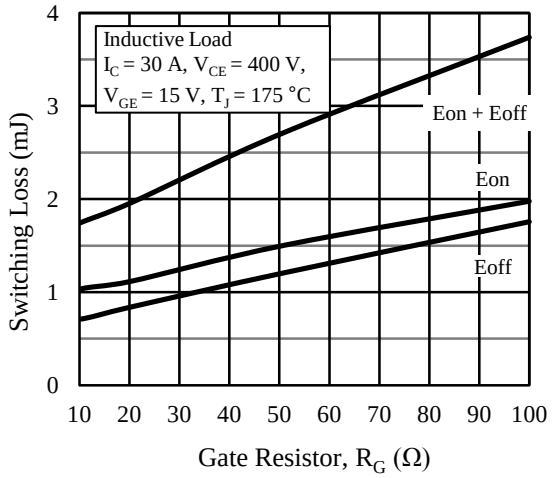



Figure 20. Switching Loss vs. Gate Resistor

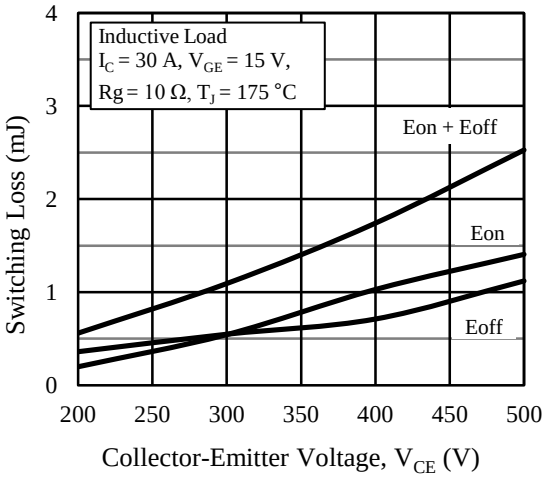



Figure 21. Switching Loss vs. Collector-Emitter Voltage

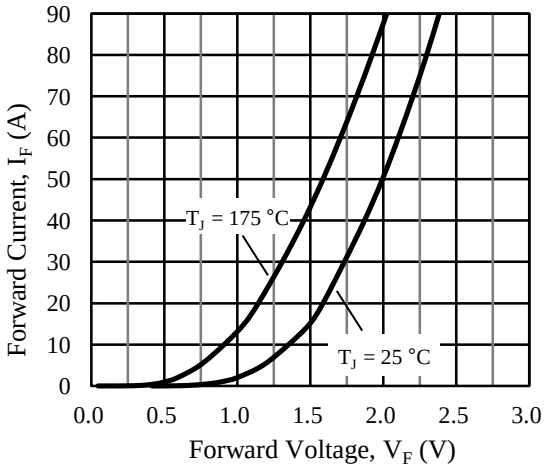



Figure 22. Diode Forward Characteristics

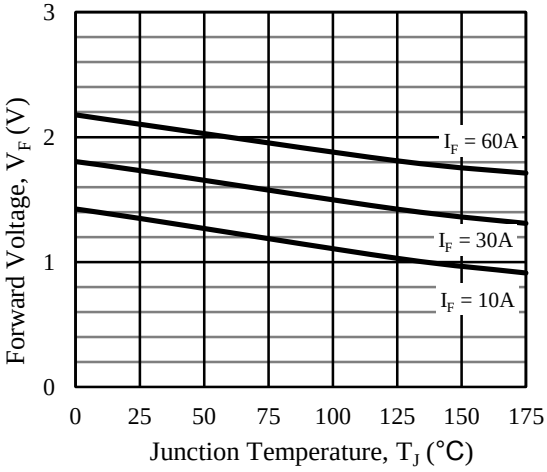



Figure 23. Diode Forward Voltage vs. Junction Temperature

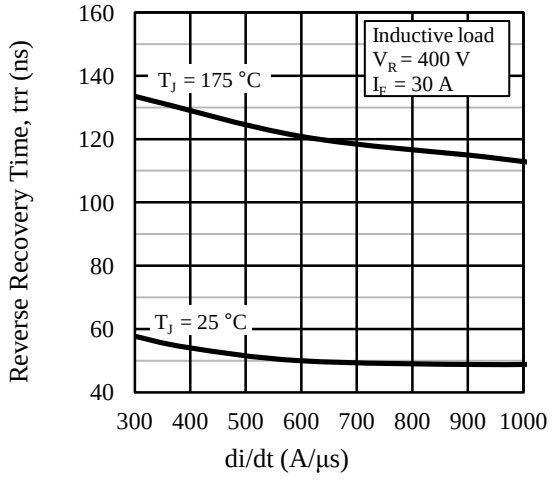



Figure 24. Diode Reverse Recovery Time vs. di/dt

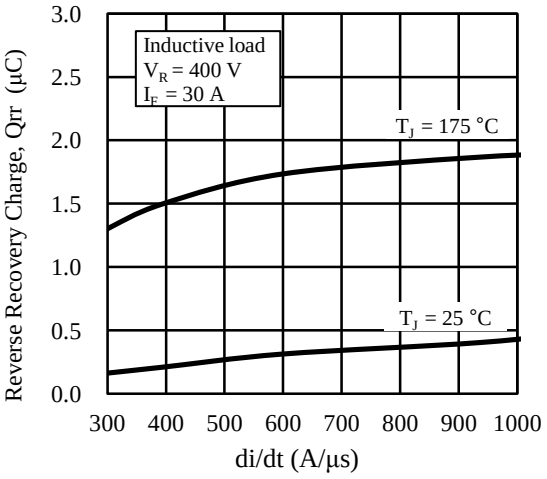



Figure 25. Diode Reverse Recovery Charge vs. di/dt

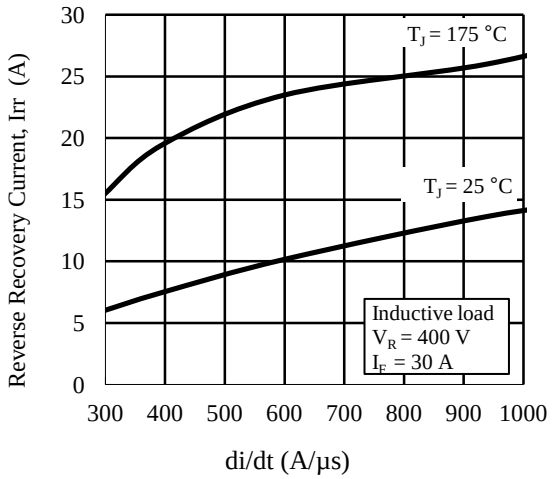



Figure 26. Diode Reverse Recovery Current vs. di/dt

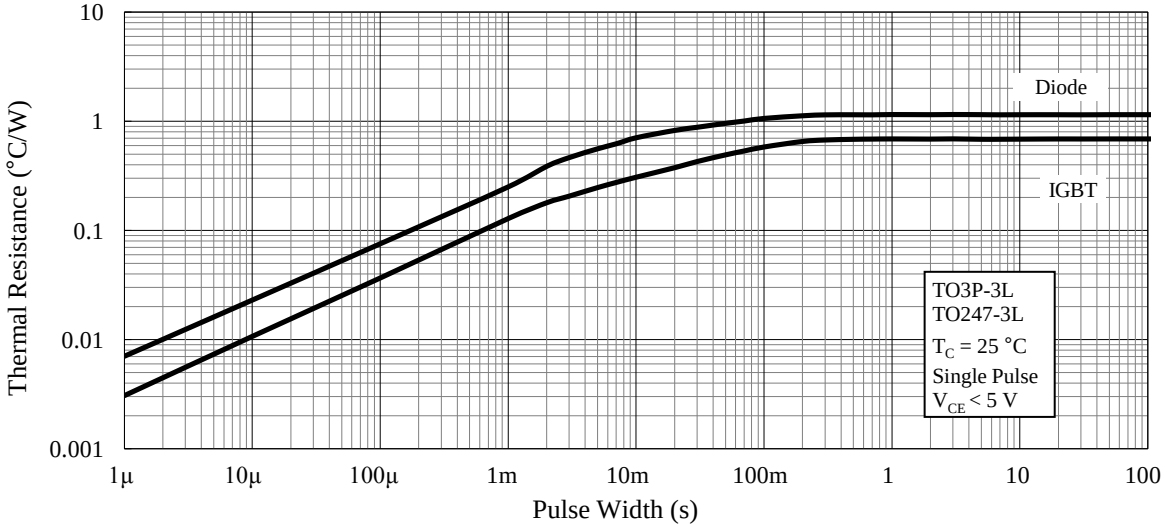



Figure 27. Transient Thermal Resistance (TO3P-3L and TO247-3L)

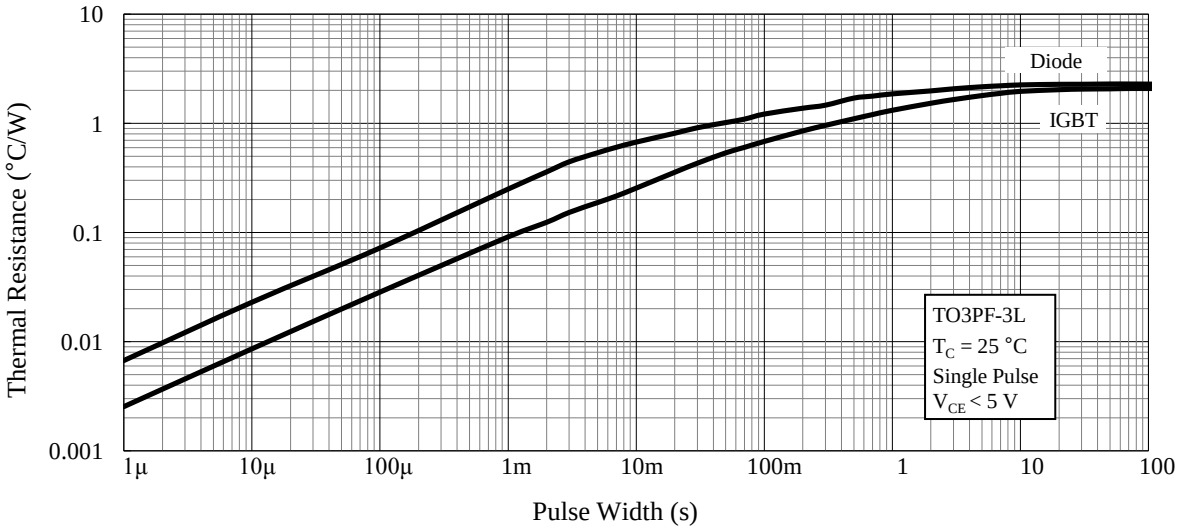
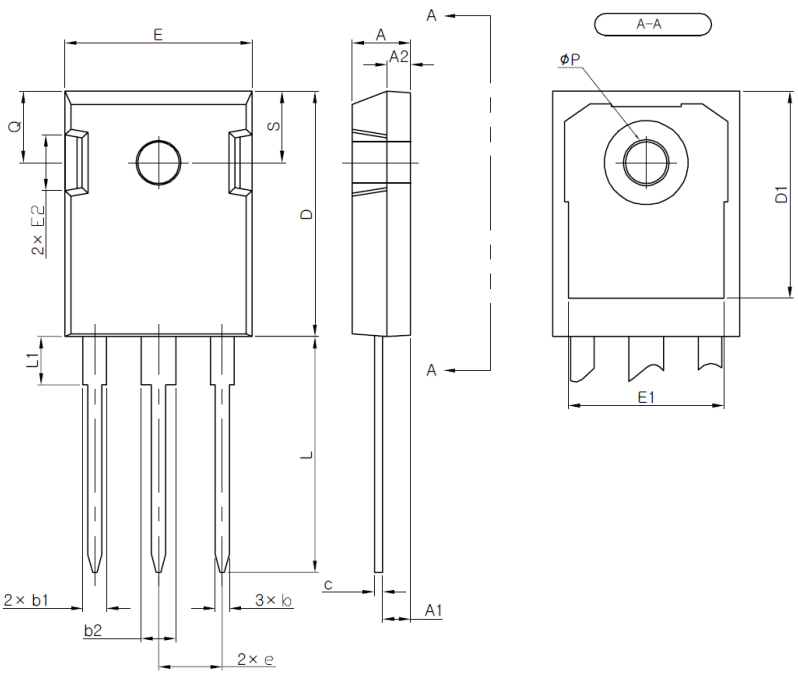



Figure 28. Transient Thermal Resistance (TO3PF-3L)

## Package Outline

- Dimensions is in millimeters.
- Pin treatment Pb-free. Device composition compliant with the RoHS directive.

TO247-3L

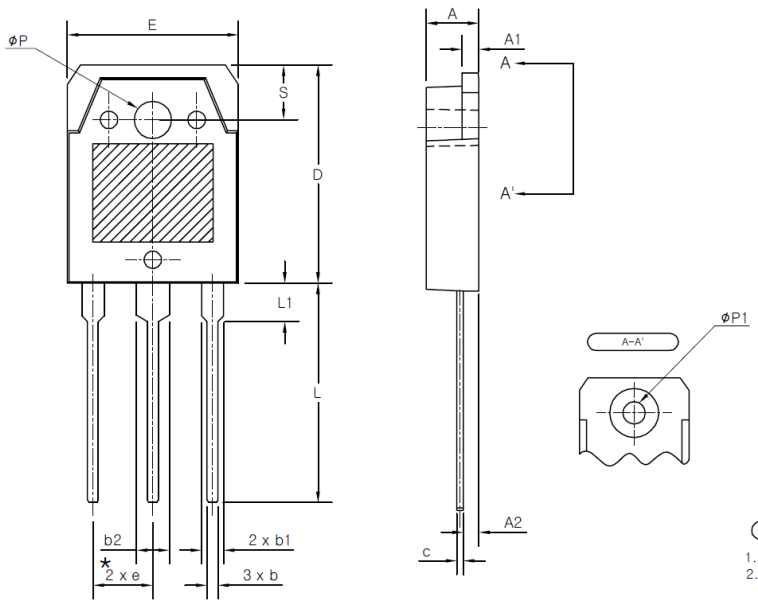



| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 4.83 | 5.02 | 5.21 |
| A1 | 2.29 | 2.41 | 2.54 |
| A2 | 1.91 | 2.04 | 2.16 |
| b | 1.14 | 1.27 | 1.40 |
| b1 | 1.91 | 2.10 | 2.20 |
| b2 | 2.92 | 3.10 | 3.20 |
| c | 0.61 | 0.71 | 0.80 |
| D | 20.80 | 21.07 | 21.34 |
| D1 | 17.43 | 17.63 | 17.83 |
| 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

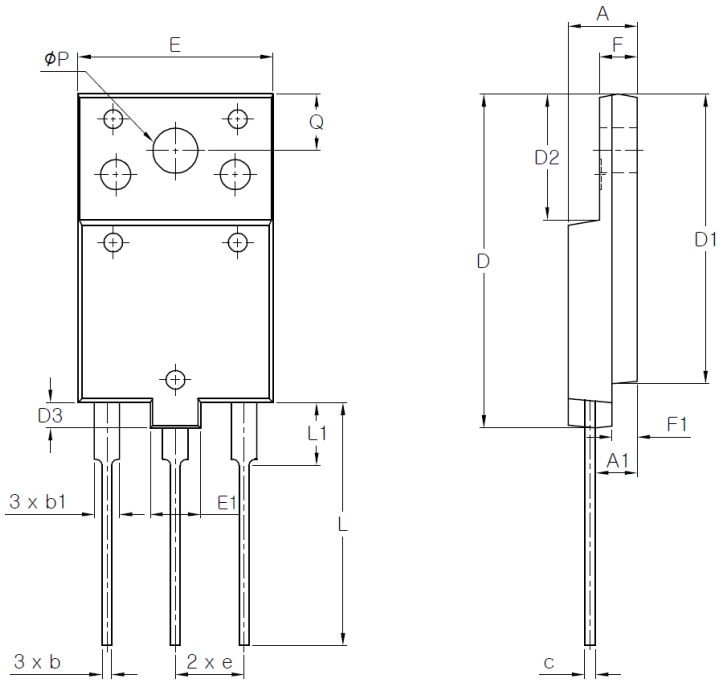



| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 4.60 | 4.80 | 5.00 |
| A1 | 1.45 | 1.50 | 1.65 |
| A2 | 1.20 | 1.40 | 1.60 |
| b | 0.80 | 1.00 | 1.20 |
| b1 | 1.80 | 2.00 | 2.20 |
| b2 | 2.80 | 3.00 | 3.20 |
| c | 0.55 | 0.60 | 0.75 |
| D | 19.70 | 19.90 | 20.10 |
| E | 15.40 | 15.60 | 15.80 |
| *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

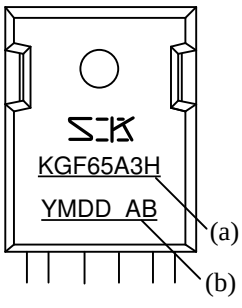
TO3PF-3L



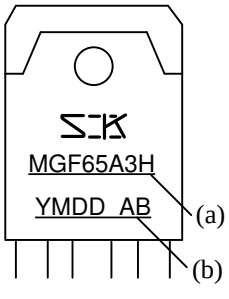

| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 5.30 | 5.50 | 5.70 |
| A1 | 3.10 | 3.30 | 3.50 |
| b | 0.65 | 0.75 | 0.95 |
| b1 | 1.80 | 2.00 | 2.20 |
| c | 0.80 | 0.90 | 1.10 |
| D | 26.30 | 26.50 | 26.70 |
| D1 | 22.80 | 23.00 | 23.20 |
| D2 | 9.80 | 10.00 | 10.20 |
| D3 | 1.80 | 2.00 | 2.20 |
| 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 |
| ϕP | 3.40 | 3.60 | 3.80 |

## Marking Diagram

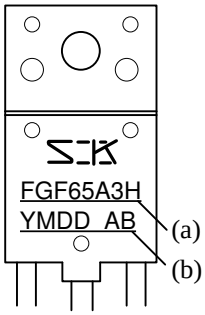
TO247-3L




TO3P-3L




TO3PF-3L




(a) Part Number

(b) Lot Number

Y is the last digit of the year (0 to 9)

M is the month (1 to 9, O, N or D)

DD is the date (two digit of 01 to 31)

A and B are Sanken control number

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