$V_{CE}$ = 650 V, $I_C$ = 15 A

**Trench Field Stop IGBTs with Fast Recovery Diode**

# FGF65A3L6L

**Data Sheet**

## Description

FGF65A3L6L is 650 V / 15 A Field Stop IGBT. Sanken original trench structure decreases gate capacitance, and achieves low saturation voltage and switching losses reduction. Thus, the Field Stop IGBT can improve the efficiency of your circuit.

## Features

- Low Saturation Voltage
- High Speed Switching
- With Integrated Fast Recovery Diode
- Bare lead frame: Pb-free (RoHS compliant)

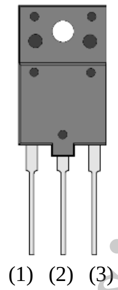
- $V_{CE}$ ---------------------------------------------------- 650 V
- $I_C$ ($T_C$ = 100 °C) ------------------------------------------ 15 A
- Short Circuit Withstand Time ------------------------- 5 µs
- $V_{CE(sat)}$ ----------------------------------------------- 1.60 V typ.
- $t_f$ ($T_J$ = 175 °C) ---------------------------------- 160 ns typ.
- $V_F$ -------------------------------------------------------- 1.5 V typ.

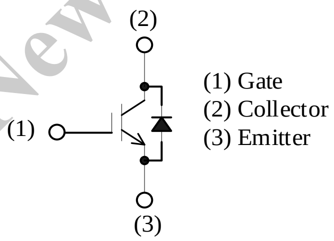
## Applications

- Uninterruptible Power Supply (UPS)
- Inverter Circuit
- Bridge Circuit

## Package

TO3PF-3L




Not to scale

## 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 | 25 | A | |
| | | $T_C$ = 100 °C | 15 | A | |
| Pulsed Collector Current | $I_{C(PULSE)}$ | PW ≤ 1 ms, duty cycle ≤ 1% | 90 | A | |
| Diode Continuous Forward Current (1) | $I_F$ | $T_C$ = 25 °C | 30 | A | |
| | | $T_C$ = 100 °C | 20 | A | |
| Diode Pulsed Forward Current | $I_{F(PULSE)}$ | PW ≤ 1 ms, duty cycle ≤ 1% | 90 | A | |
| Short Circuit Withstand Time | $t_{SC}$ | $V_{GE}$ = 15 V, $V_{CE}$ = 400 V $T_J$ = 175 °C | 5 | µs | |
| Power Dissipation | $P_D$ | $T_C$ = 25 °C | 72 | W | |
| Operating Junction Temperature | $T_J$ | | 175 | °C | |
| Storage Temperature Range | $T_{STG}$ | | −55 to 150 | °C | |
| Isolation Voltage (RMS) | $V_{ISO(RMS)}$ | (2) | 1500 | V | |
| Isolation Voltage | $V_{ISO(RMS)}$ | Between surface of case and all pins that are shorted; AC, 60 Hz, 1 min | 1500 | V | |



## Thermal Characteristics

Unless otherwise specified, $T_A$ = 25 °C

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

(1) $I_C$ and $I_F$ are determined by the maximum junction temperature for TO3P-3L package.
(2) Between surface of the device and each pin; AC, 60 Hz, 1 min.

## Electrical Characteristics

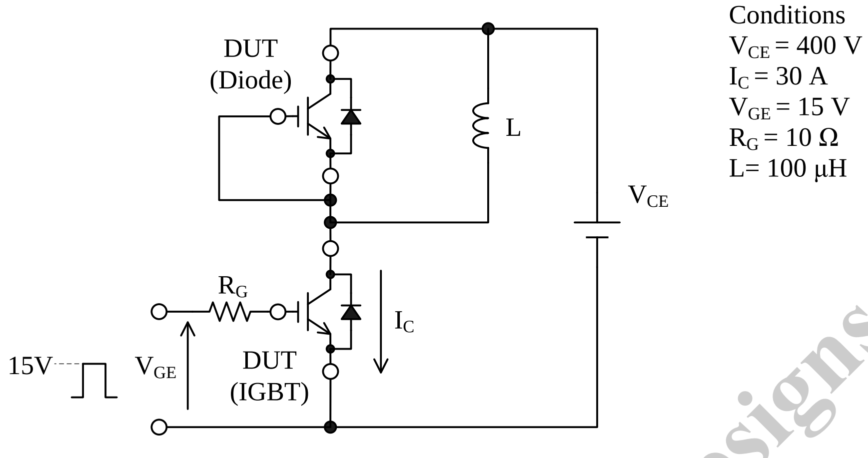
Unless otherwise specified, $T_A$ = 25 °C

| 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, $I_C$ = 30 A | — | 1.60 | 1.96 | V |
| Input Capacitance | $C_{ies}$ | $V_{CE}$ = 20 V, $V_{GE}$ = 0 V, 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, $V_{GE}$ = 15 V | — | 60 | — | nC |
| Turn-on Delay Time | $t_{d(on)}$ | $T_J$ = 25 °C, see Figure 1. | — | 30 | — | ns |
| Rise Time | $t_r$ | | — | 30 | — | |
| Turn-off Delay Time | $t_{d(off)}$ | | — | 90 | — | |
| Fall Time | $t_f$ | | — | 40 | — | |
| Turn-on Energy (3) | $E_{on}$ | | — | 0.6 | — | mJ |
| Turn-off Energy | $E_{off}$ | | — | 0.6 | — | |
| Turn-on Delay Time | $t_{d(on)}$ | $T_J$ = 175 °C, see Figure 1. | — | 30 | — | ns |
| Rise Time | $t_r$ | | — | 30 | — | |
| Turn-off Delay Time | $t_{d(off)}$ | | — | 120 | — | |
| Fall Time | $t_f$ | | — | 160 | — | |
| Turn-on Energy (3) | $E_{on}$ | | — | 1.1 | — | mJ |
| Turn-off Energy | $E_{off}$ | | — | 1.1 | — | |
| Emitter to Collector Diode Forward Voltage | $V_F$ | $I_F$ = 30 A | — | 1.5 | — | V |
| Emitter to Collector Diode Reverse Recovery Time | $t_{rr}$ | $I_F$ = 30 A, di/dt = 700 A/µs | — | 70 | — | ns |

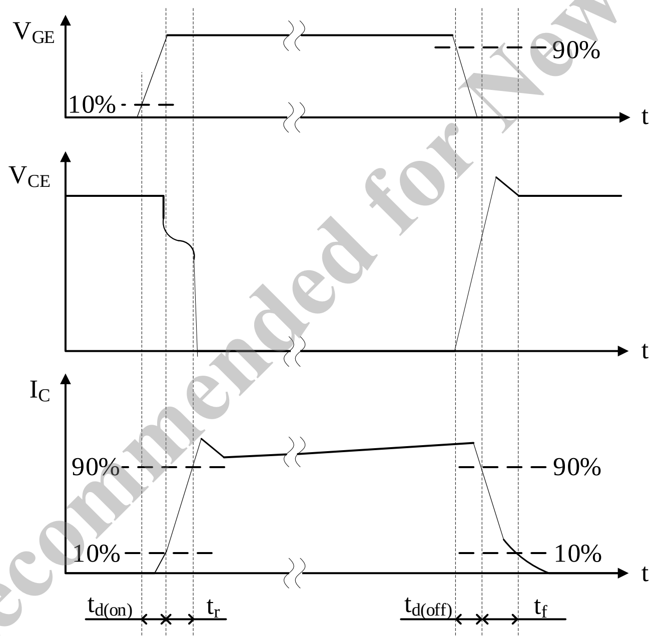


(3) Energy losses include the reverse recovery of diode.

## Test Circuits and Waveforms




(a) Test Circuit




(b) Waveform

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

## Rating and Characteristic Curves

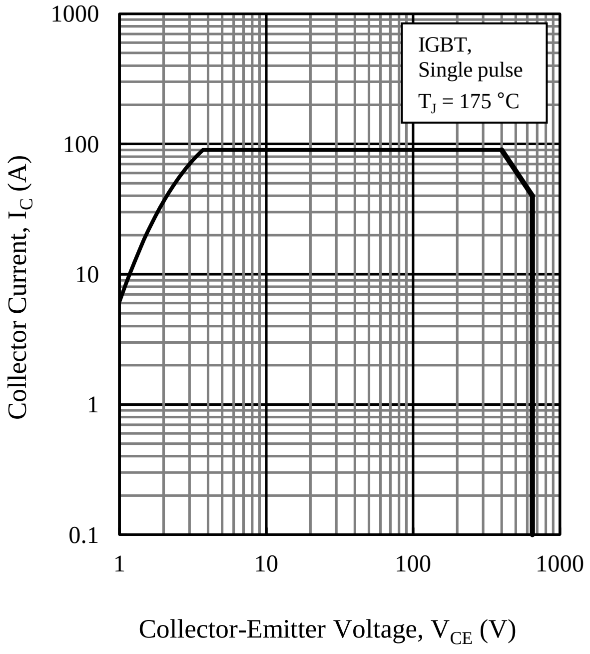



Figure 2. IGBT Reverse Bias Safe Operating Area

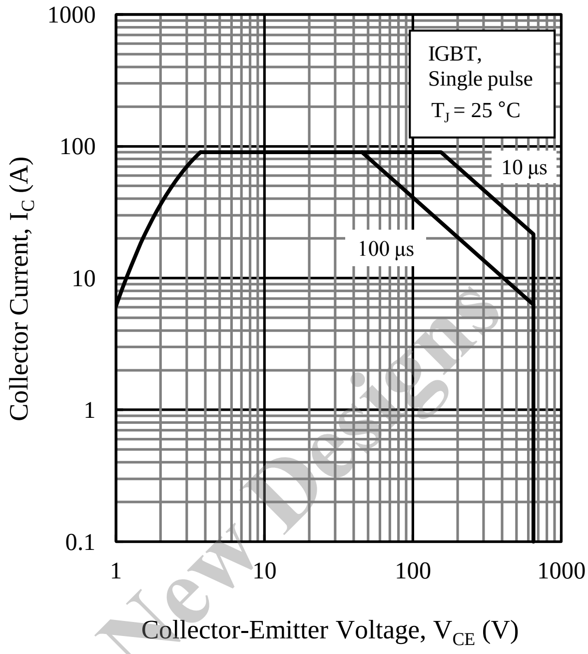



Figure 3. IGBT Safe Operating Area

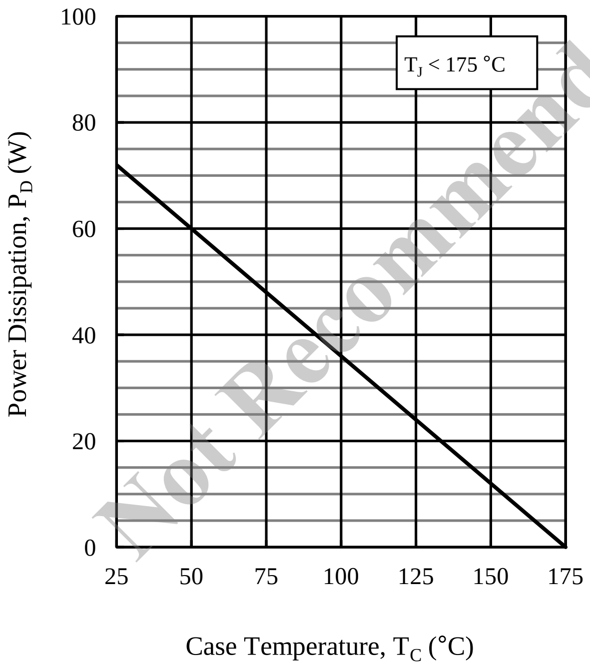



Figure 4. Power Dissipation vs. Case Temperature

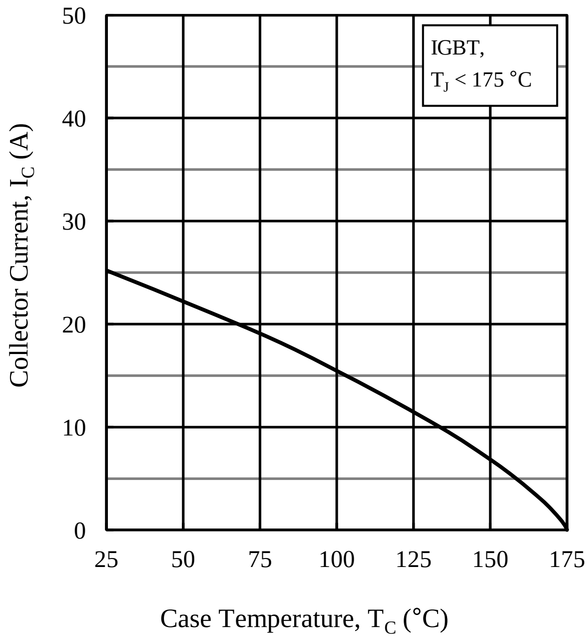



Figure 5. Collector Current vs. Case Temperature

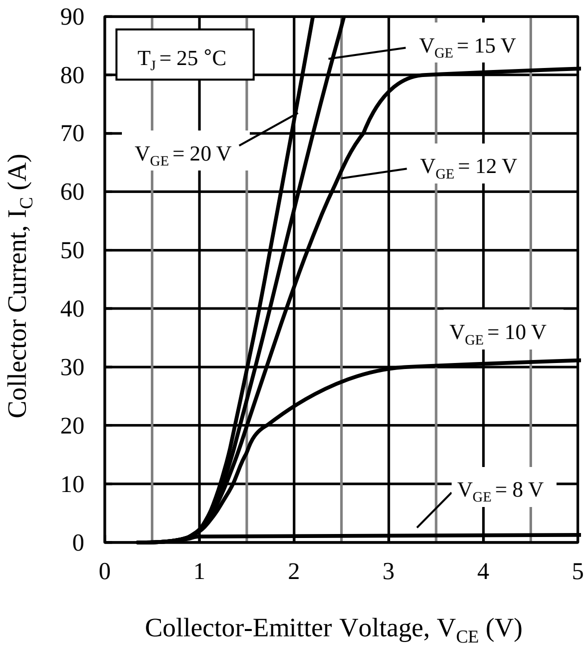



Figure 6. Output Characteristics ($T_J$ = 25 °C)

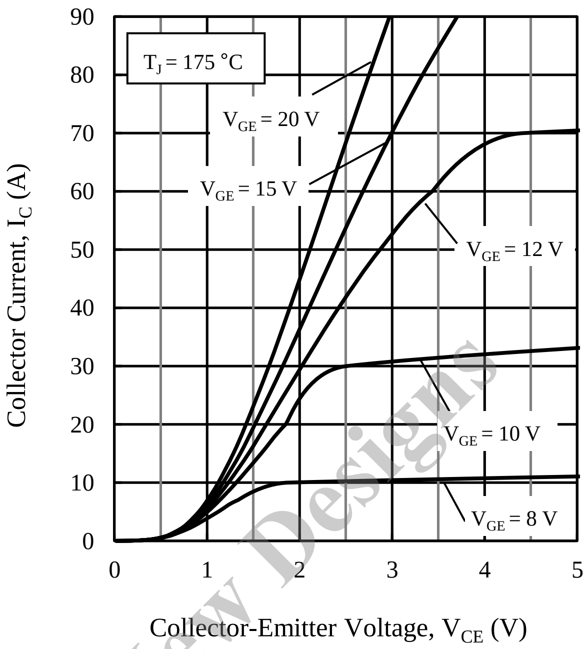



Figure 7. Output Characteristics ($T_J$ = 175 °C)

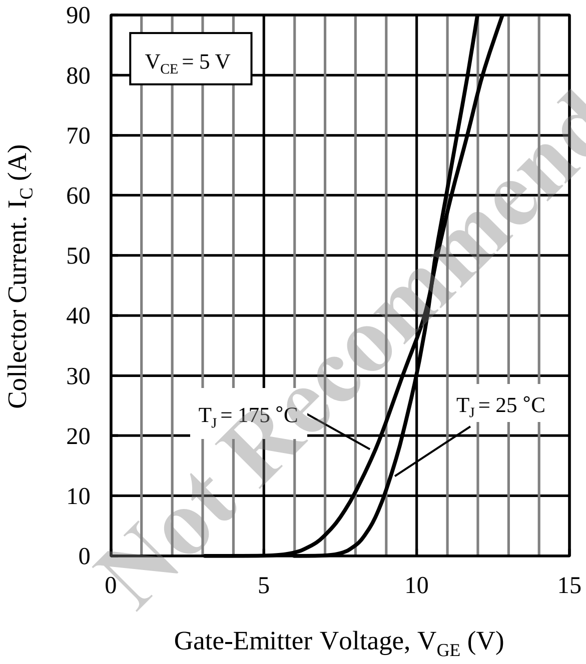



Figure 8. Transfer Characteristics

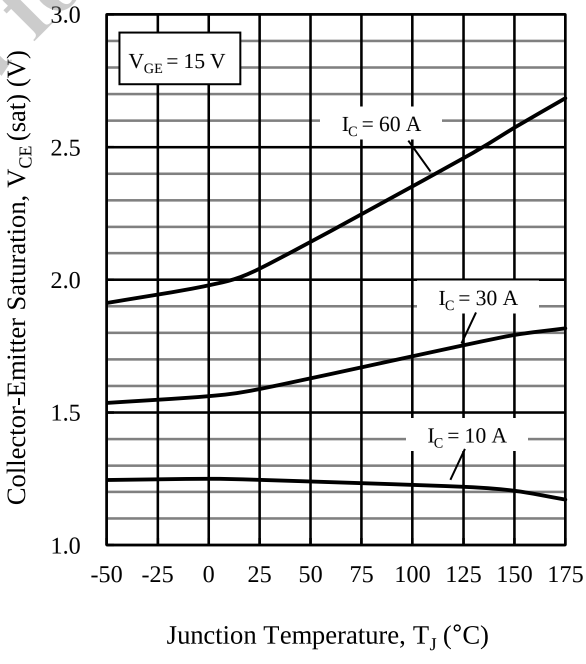



Figure 9. Saturation Voltage vs. Junction Temperature

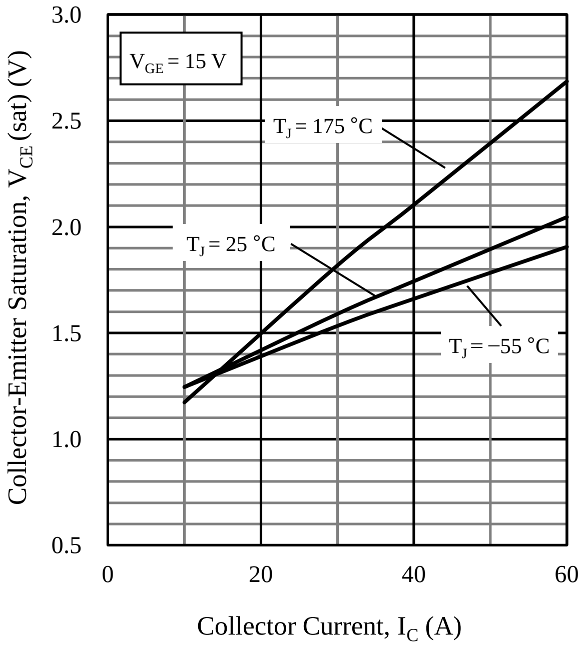



Figure 10. Saturation Voltage vs. Collector Current

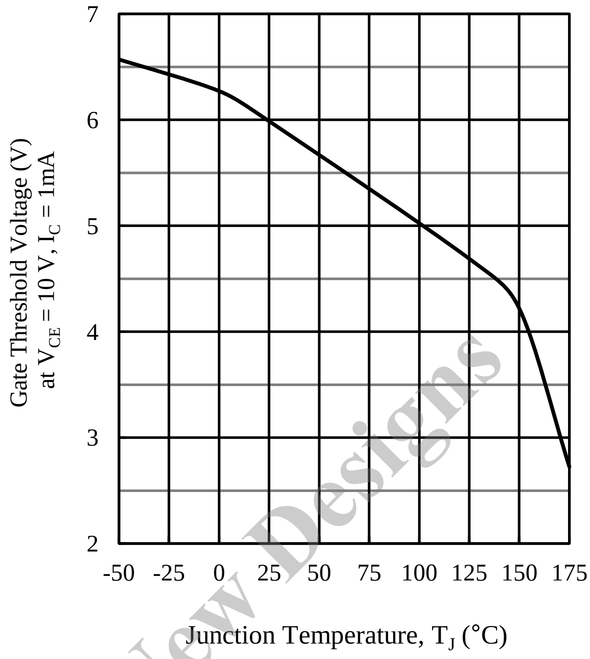



Figure 11. Gate Threshold Voltage vs. Junction Temperature

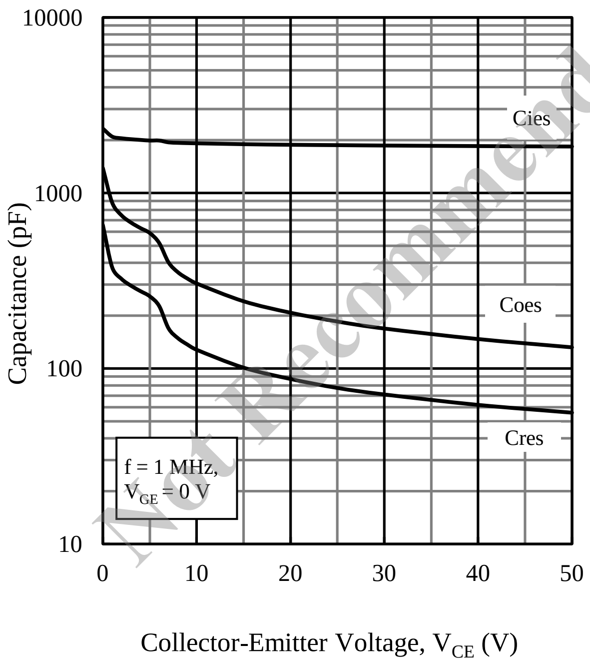



Figure 12. Capacitance Characteristics

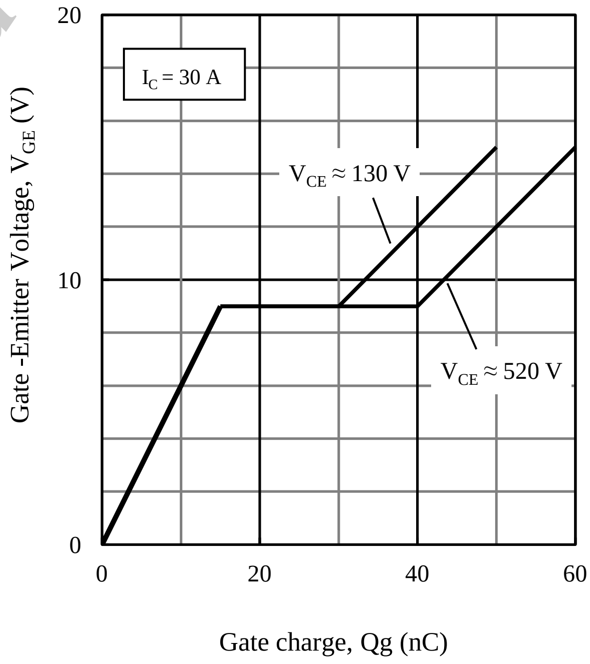



Figure 13. Typical Gate Charge

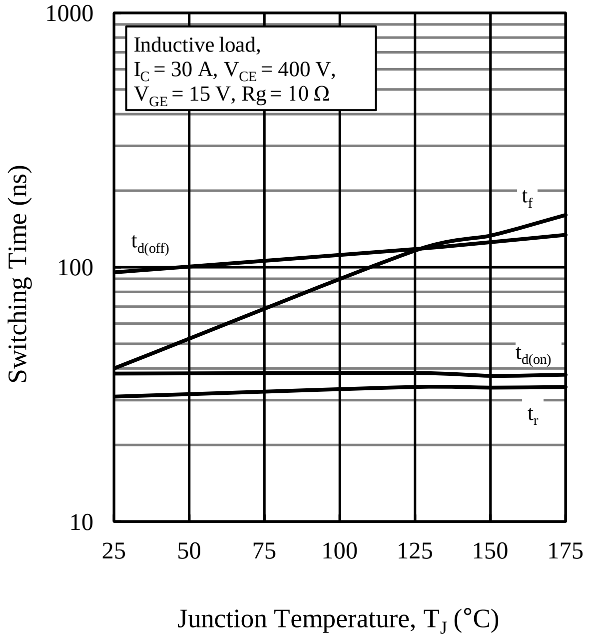



Figure 14. Switching Time vs. Junction Temperature

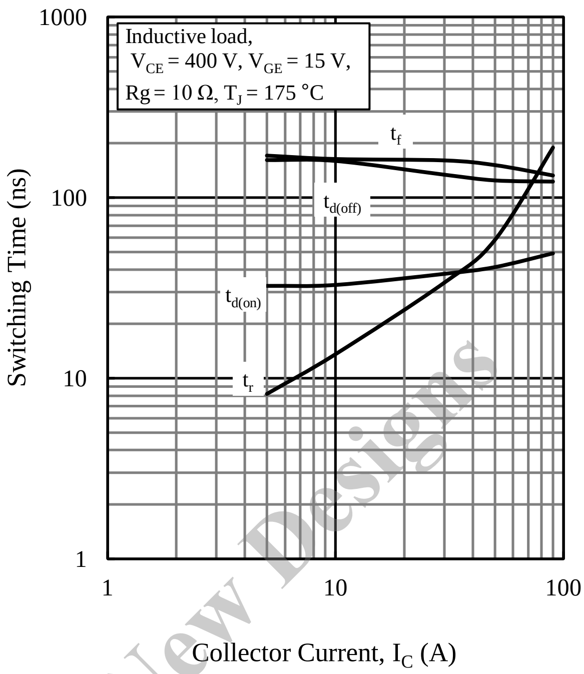



Figure 15. Switching Time vs. Collector Current

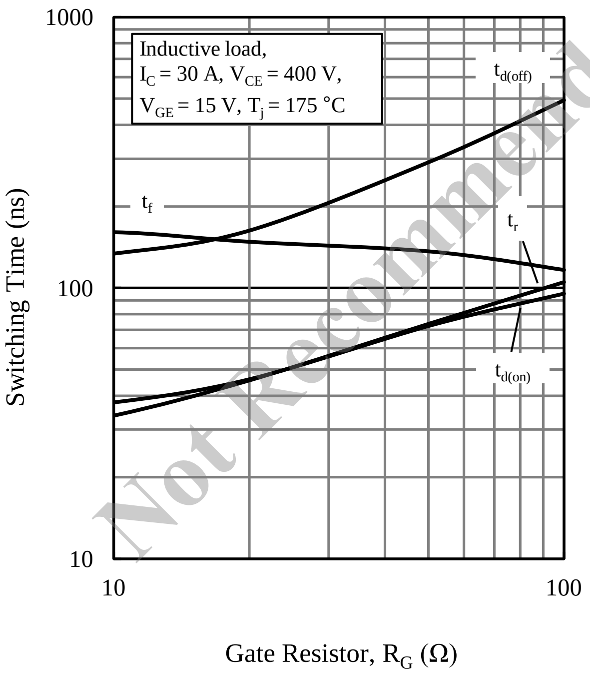



Figure 16. Switching Time vs. Gate Resistor

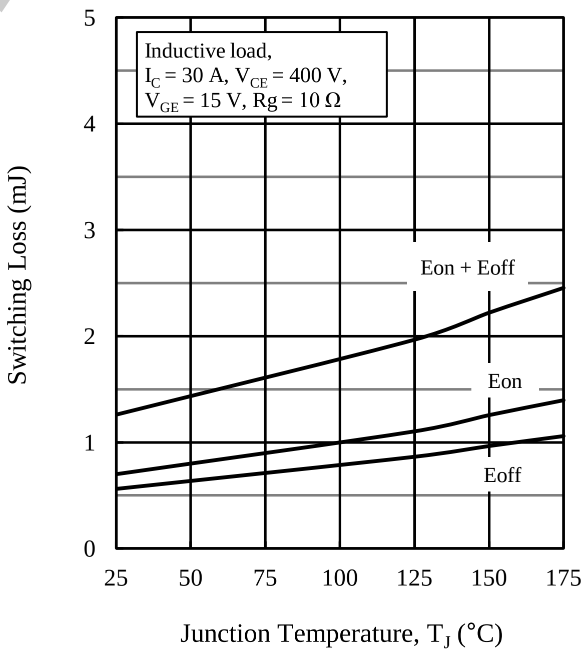



Figure 17. Switching Loss vs. Junction Temperature

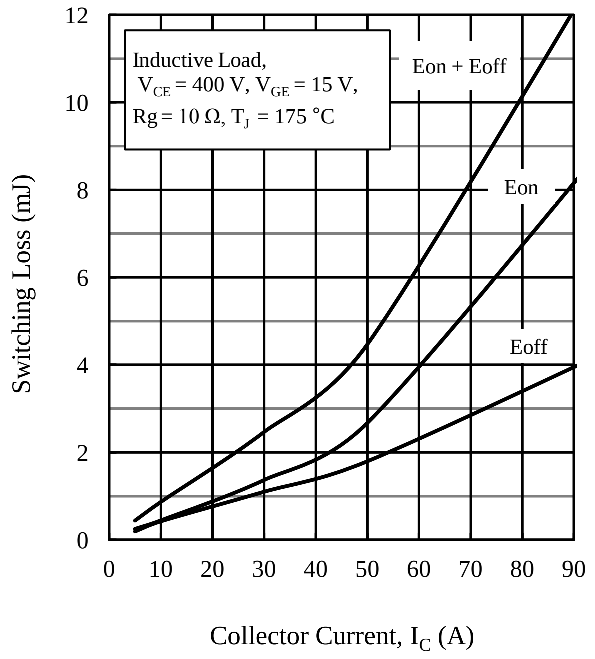



Figure 18. Switching Loss vs. Collector Current

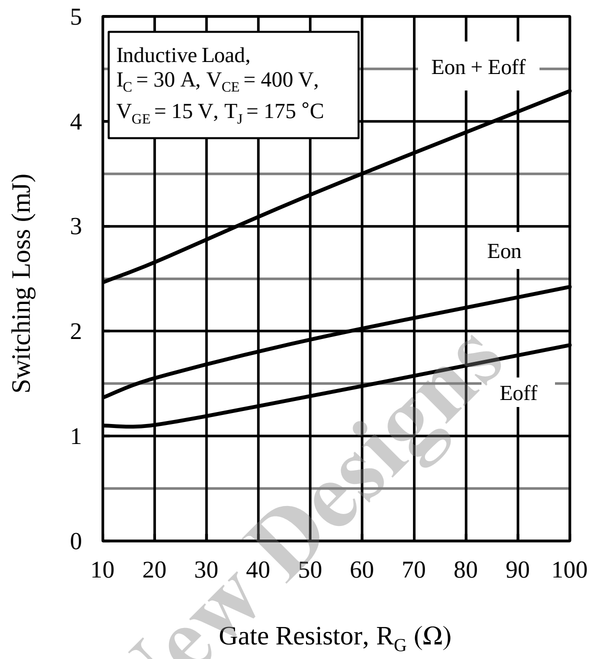



Figure 19. Switching Loss vs. Gate Resistor

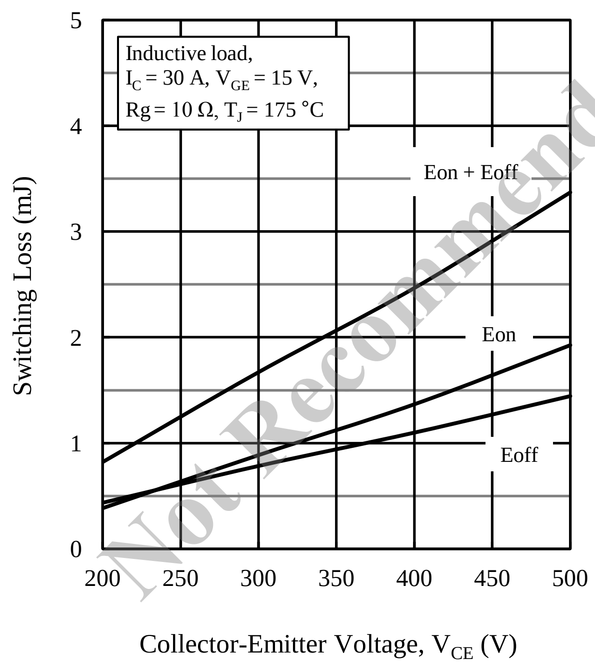



Figure 20. Switching Loss vs. Collector-Emitter Voltage

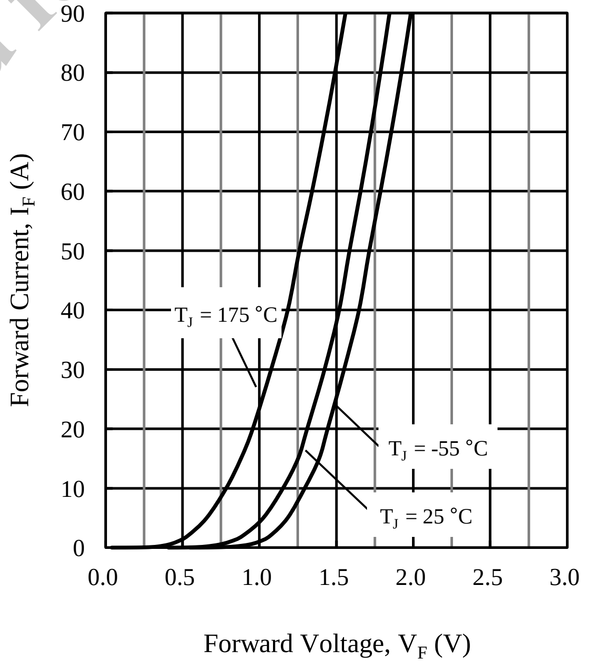



Figure 21. Diode Forward Characteristics

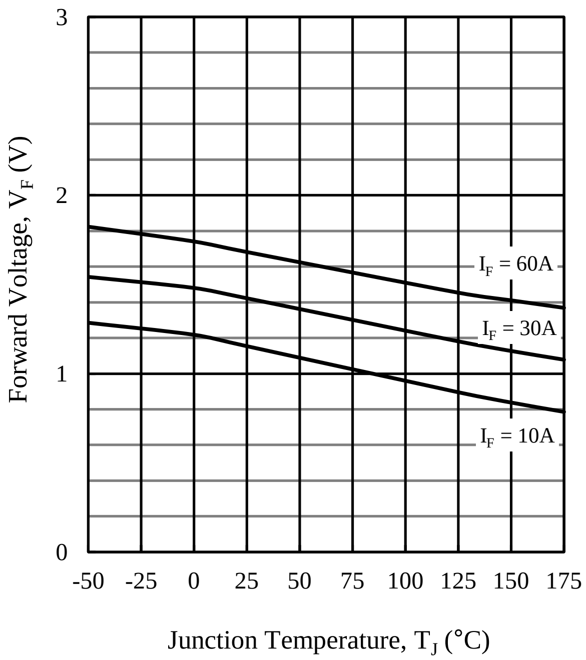



Figure 22. Diode Forward Voltage vs. Junction Temperature

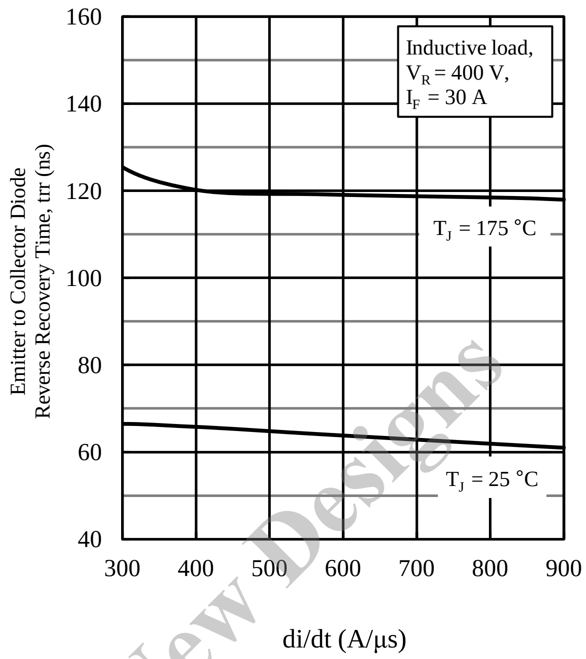



Figure 23. Emitter to Collector Diode Reverse Recovery Time vs. di/dt



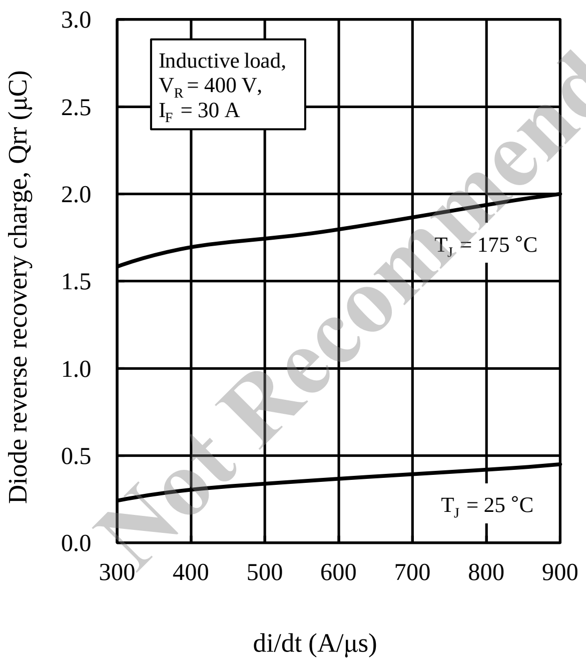



Figure 24. Diode Reverse Recovery Charge vs. di/dt

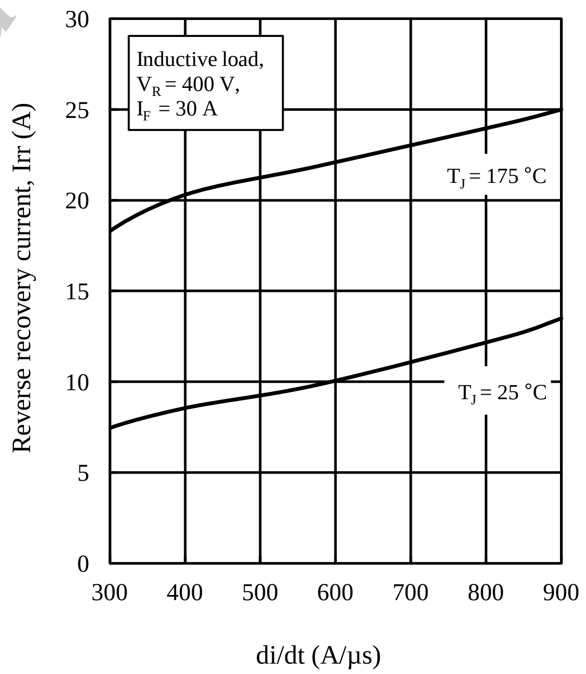



Figure 25. Recovery Current vs. di/dt

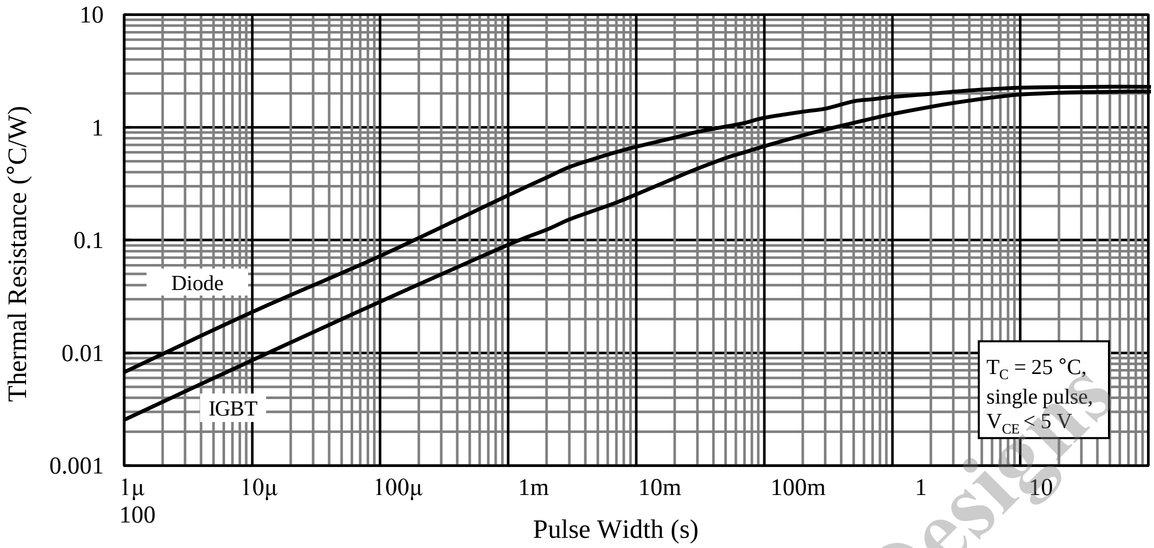
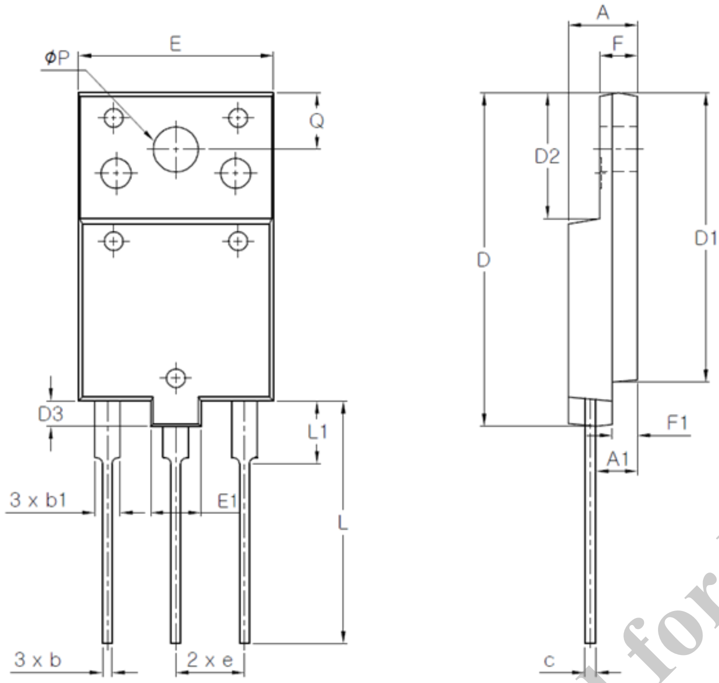



Figure 26. Transient Thermal Resistance

## Physical Dimensions

● **TO3PF-3L**



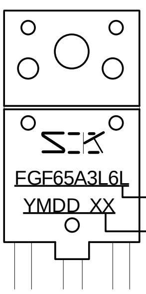

| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 5.30 | 5.50 | 5.70 |
| A1 | 3.10 | 3.30 | 3.50 |
| b | 0.65 | 0.75 | 0.95 |
| b1 | 1.80 | 2.00 | 2.20 |
| c | 0.80 | 0.90 | 1.10 |
| D | 26.30 | 26.50 | 26.70 |
| D1 | 22.80 | 23.00 | 23.20 |
| D2 | 9.80 | 10.00 | 10.20 |
| D3 | 1.80 | 2.00 | 2.20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

**NOTES:**

- Dimensions in millimeters
- Bare lead frame: 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 product.)
- Recommended screw torque for TO3PF: 0.686 N·m to 0.882 N·m (7 kgf·cm to 9 kgf·cm)



## Marking Diagram




Part Number

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)
X is the control number

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- No anti-radioactive ray design has been adopted for the Sanken Products.
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