

**$V_{CE} = 650\text{ V}$ ,  $I_C = 40\text{ A}$**   
**Trench Field Stop IGBTs with Fast Recovery Diode**  
**KGF65A4L, MGF65A4L, FGF65A4L**

**Description**

KGF65A4L, MGF65A4L, and FGF65A4L are 650 V Field Stop IGBTs. Sanken original trench structure decreases gate capacitance, and achieves low saturation voltage and switching losses reduction. Thus, Field Stop IGBTs can improve the efficiency of your circuit.

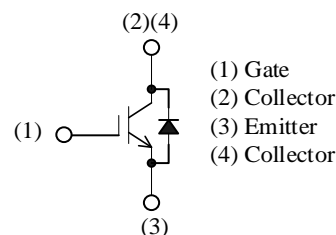
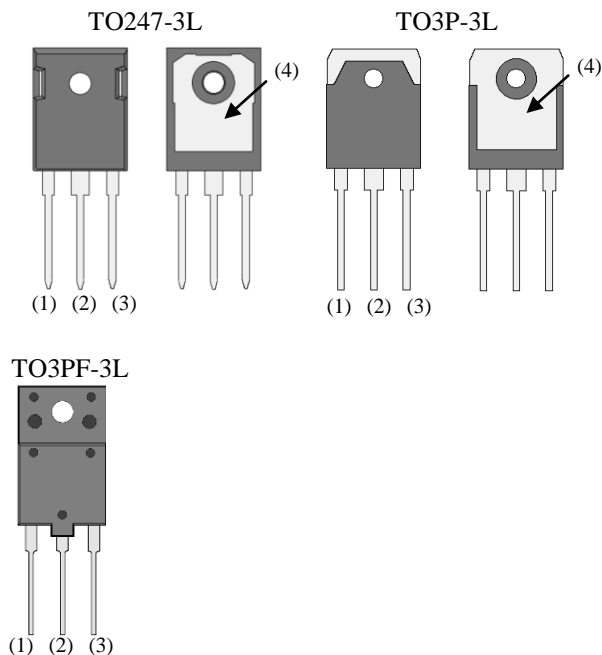
**Features**

- Low Saturation Voltage
  - High Speed Switching
  - With Integrated Fast Recovery Diode
  - Bare lead frame: Pb-free (RoHS compliant)
- 
- $V_{CE}$ ----- 650 V
  - $I_C$  ( $T_C = 100\text{ }^\circ\text{C}$ )----- 40 A
  - Short Circuit Withstand Time ----- 5  $\mu\text{s}$
  - $V_{CE(sat)}$ ----- 1.6 V typ.
  - $t_f$  ( $T_J = 175\text{ }^\circ\text{C}$ ) ----- 160 ns typ.
  - $V_F$ ----- 1.7 V typ.

**Applications**

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

**Package**



Not to scale

**Selection Guide**

Part Number	Package
KGF65A4L	TO247-3L
MGF65A4L	TO3P-3L
FGF65A4L	TO3PF-3L

## KGF65A4L, MGF65A4L, FGF65A4L

### Absolute Maximum Ratings

Unless otherwise specified,  $T_A = 25\text{ }^\circ\text{C}$

Parameter	Symbol	Conditions	Rating	Unit	Remarks
Collector to Emitter Voltage	$V_{CE}$		650	V	
Gate to Emitter Voltage	$V_{GE}$		$\pm 30$	V	
Continuous Collector Current <sup>(1)</sup>	$I_C$	$T_C = 25\text{ }^\circ\text{C}$	65	A	
		$T_C = 100\text{ }^\circ\text{C}$	40	A	
Pulsed Collector Current	$I_{C(PULSE)}$	$PW \leq 1\text{ ms}$ , duty cycle $\leq 1\%$	120	A	
Diode Continuous Forward Current <sup>(1)</sup>	$I_F$	$T_C = 25\text{ }^\circ\text{C}$	40 <sup>(2)</sup>	A	
		$T_C = 100\text{ }^\circ\text{C}$	40	A	
Diode Pulsed Forward Current	$I_{F(PULSE)}$	$PW \leq 1\text{ ms}$ , duty cycle $\leq 1\%$	120	A	
Short Circuit Withstand Time	$t_{SC}$	$V_{GE} = 15\text{ V}$ , $V_{CE} = 400\text{ V}$ $T_J = 175\text{ }^\circ\text{C}$	5	$\mu\text{s}$	
Power Dissipation	$P_D$	$T_C = 25\text{ }^\circ\text{C}$	288	W	MGF65A4L KGF65A4L FGF65A4L
			72		
Operating Junction Temperature	$T_J$		175	$^\circ\text{C}$	
Storage Temperature Range	$T_{STG}$		-55 to 150	$^\circ\text{C}$	
Isolation Voltage	$V_{ISO(RMS)}$	Between surface of case and all pins that are shorted; AC, 60 Hz, 1 min	1500	V	FGF65A4L

### Thermal Characteristics

Unless otherwise specified,  $T_A = 25\text{ }^\circ\text{C}$

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	Remarks
Thermal Resistance of IGBT (Junction to Case)	$R_{\theta JC}$ (IGBT)		—	—	0.52	$^\circ\text{C/W}$	MGF65A4L KGF65A4L FGF65A4L
			—	—	2.08		
Thermal Resistance of Diode (Junction to Case)	$R_{\theta JC}$ (Di)		—	—	1.15	$^\circ\text{C/W}$	MGF65A4L KGF65A4L FGF65A4L
			—	—	2.28		

<sup>(1)</sup>  $I_C$  and  $I_F$  are determined by the maximum junction temperature for TO3P-3L package.

<sup>(2)</sup> Determined by bonding wires capability.

## KGF65A4L, MGF65A4L, FGF65A4L

### Electrical Characteristics

Unless otherwise specified,  $T_A = 25\text{ }^\circ\text{C}$

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	
Collector to Emitter Breakdown Voltage	$V_{(BR)CES}$	$I_C = 100\text{ }\mu\text{A}$ , $V_{GE} = 0\text{ V}$	650	—	—	V	
Collector to Emitter Leakage Current	$I_{CES}$	$V_{CE} = 650\text{ V}$ , $V_{GE} = 0\text{ V}$	—	—	100	$\mu\text{A}$	
Gate to Emitter Leakage Current	$I_{GES}$	$V_{GE} = \pm 30\text{ V}$	—	—	$\pm 500$	nA	
Gate Threshold Voltage	$V_{GE(TH)}$	$V_{CE} = 10\text{ V}$ , $I_C = 1\text{ mA}$	4.0	5.5	7.0	V	
Collector to Emitter Saturation Voltage	$V_{CE(sat)}$	$V_{GE} = 15\text{ V}$ , $I_C = 40\text{ A}$	—	1.6	1.96	V	
Input Capacitance	$C_{ies}$	$V_{CE} = 20\text{ V}$ , $V_{GE} = 0\text{ V}$ , $f = 1.0\text{ MHz}$ ,	—	2300	—	pF	
Output Capacitance	$C_{oes}$		—	250	—		
Reverse Transfer Capacitance	$C_{res}$		—	110	—		
Gate charge	$Q_g$	$V_{CE} = 520\text{ V}$ , $I_C = 40\text{ A}$ , $V_{GE} = 15\text{ V}$	—	75	—	nC	
Turn-on Delay Time	$t_{d(on)}$	$T_J = 25\text{ }^\circ\text{C}$ , see Figure 1.	—	40	—	ns	
Rise Time	$t_r$		—	40	—		
Turn-off Delay Time	$t_{d(off)}$		—	100	—		
Fall Time	$t_f$		—	50	—		
Turn-on Energy <sup>(3)</sup>	$E_{on}$		—	0.9	—		mJ
Turn-off Energy	$E_{off}$	—	0.9	—			
Turn-on Delay Time	$t_{d(on)}$	$T_J = 175\text{ }^\circ\text{C}$ , see Figure 1.	—	40	—	ns	
Rise Time	$t_r$		—	40	—		
Turn-off Delay Time	$t_{d(off)}$		—	130	—		
Fall Time	$t_f$		—	160	—		
Turn-on Energy <sup>(3)</sup>	$E_{on}$		—	1.6	—		mJ
Turn-off Energy	$E_{off}$		—	1.6	—		
Emitter to Collector Diode Forward Voltage	$V_F$	$I_F = 40\text{ A}$	—	1.7	—	V	
Emitter to Collector Diode Reverse Recovery Time	$t_{rr}$	$I_F = 40\text{ A}$ , $di/dt = 600\text{ A}/\mu\text{s}$	—	60	—	ns	

<sup>(3)</sup> Energy losses include the reverse recovery of diode.

Test Circuits and Waveforms

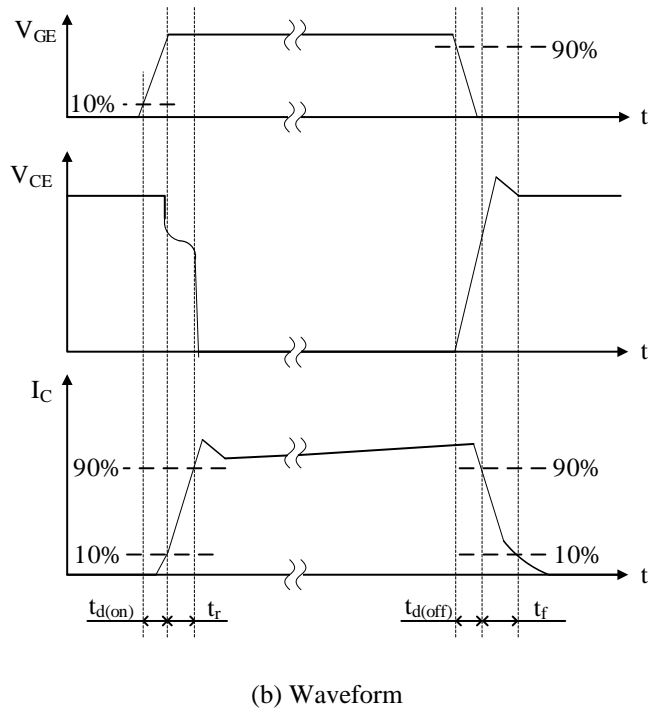
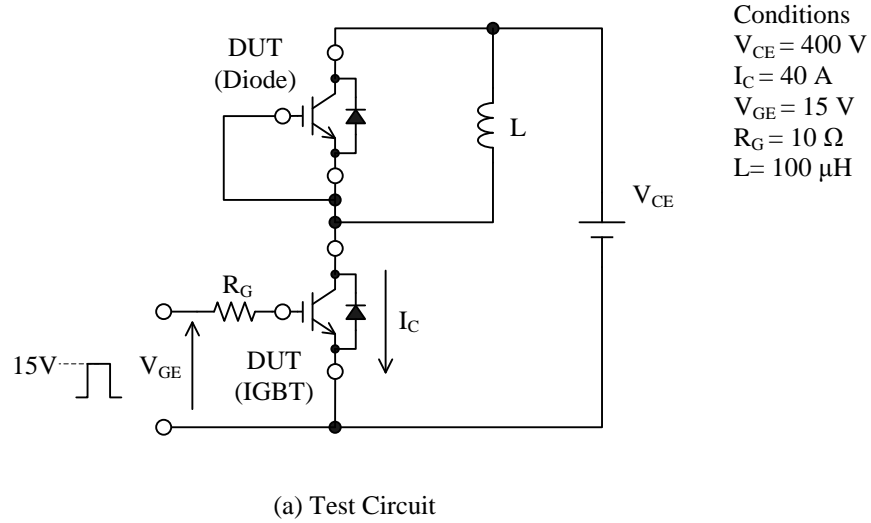


Figure 1. Test Circuits and Waveforms of dv/dt and Switching Time

Rating and Characteristic Curves

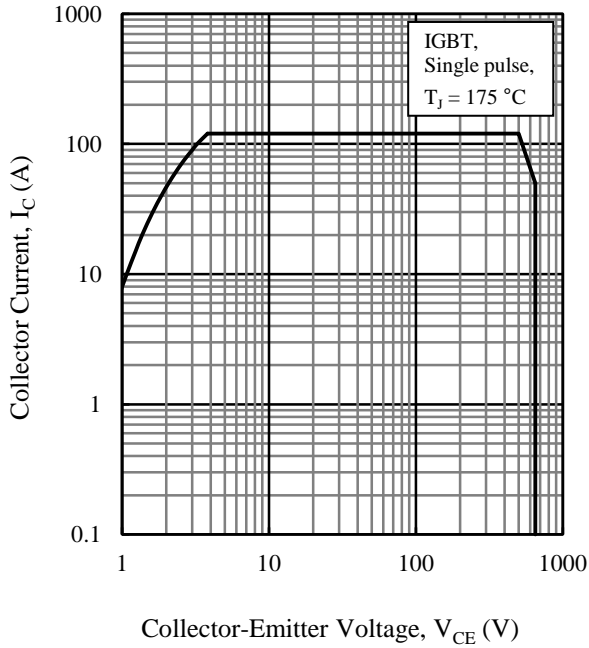


Figure 2. IGBT Reverse Bias Safe Operating Area

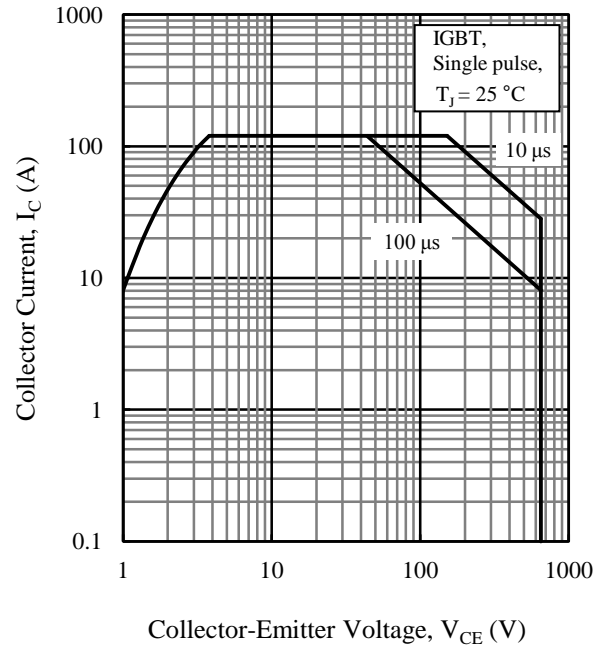


Figure 3. IGBT Safe Operating Area

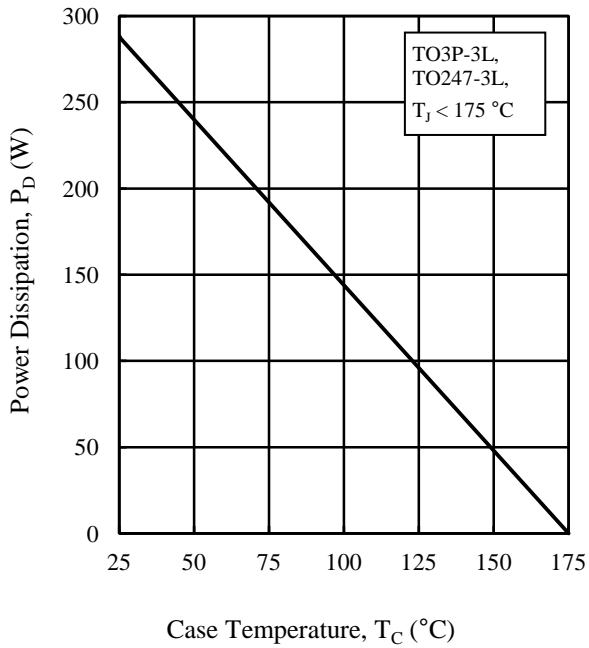


Figure 4. Power Dissipation vs. Case Temperature

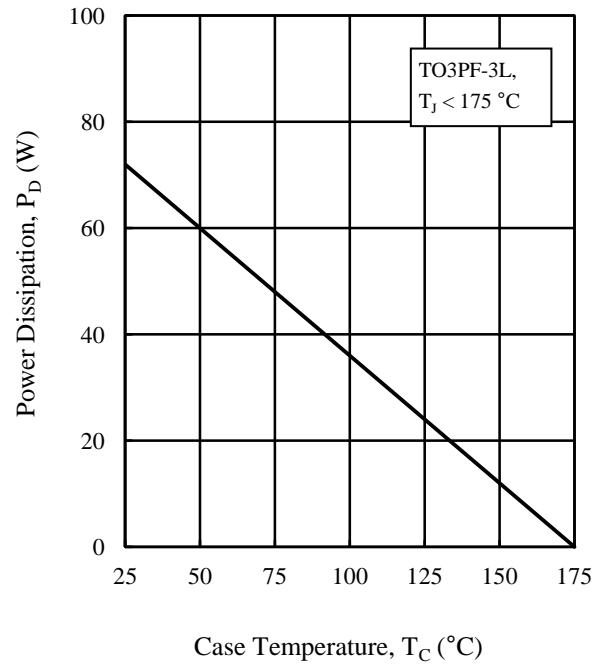


Figure 5. Power Dissipation vs. Case Temperature

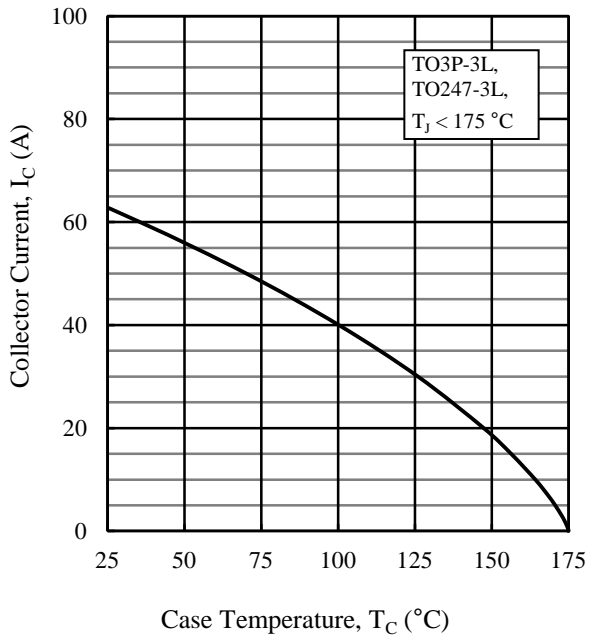


Figure 6. Collector Current vs. Case Temperature

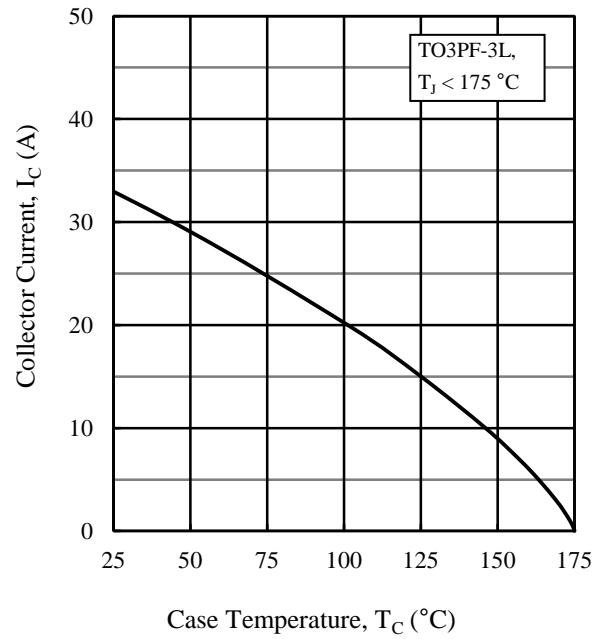


Figure 7. Collector Current vs. Case Temperature

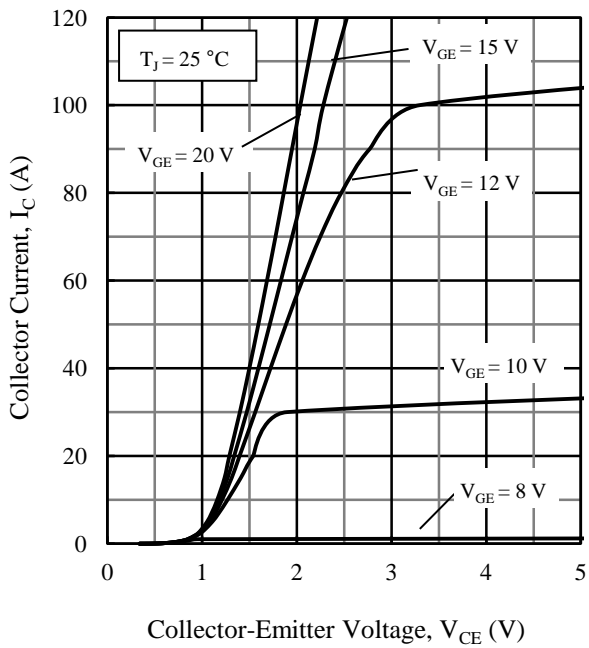


Figure 8. Output Characteristics ( $T_J = 25\text{ °C}$ )

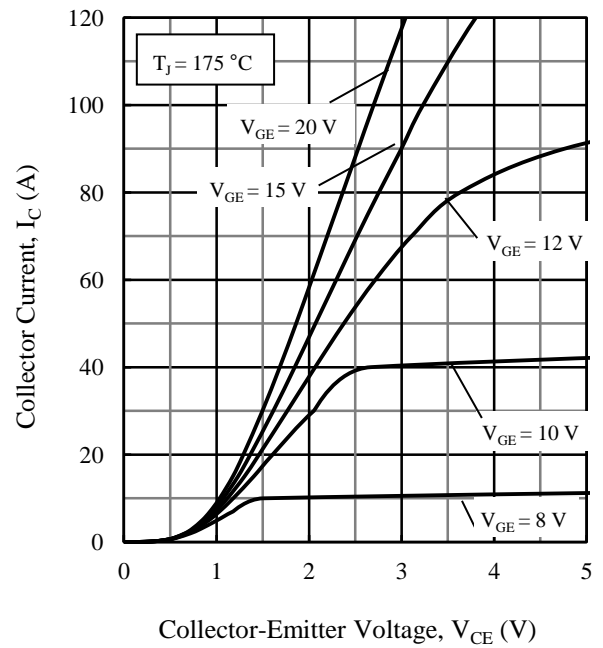


Figure 9. Output Characteristics ( $T_J = 175\text{ °C}$ )

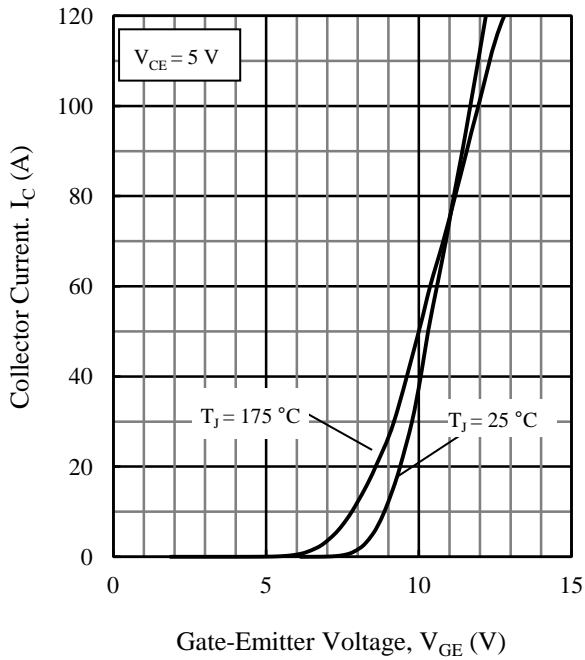


Figure 10. Transfer Characteristics

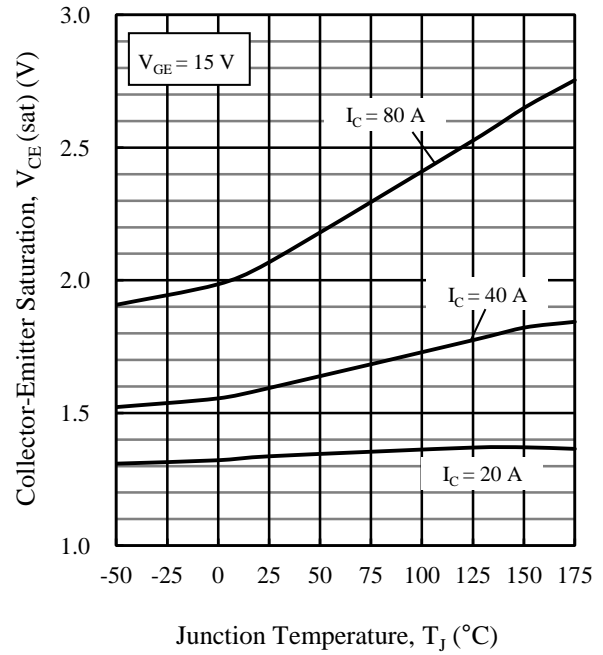


Figure 11. Saturation Voltage vs. Junction Temperature

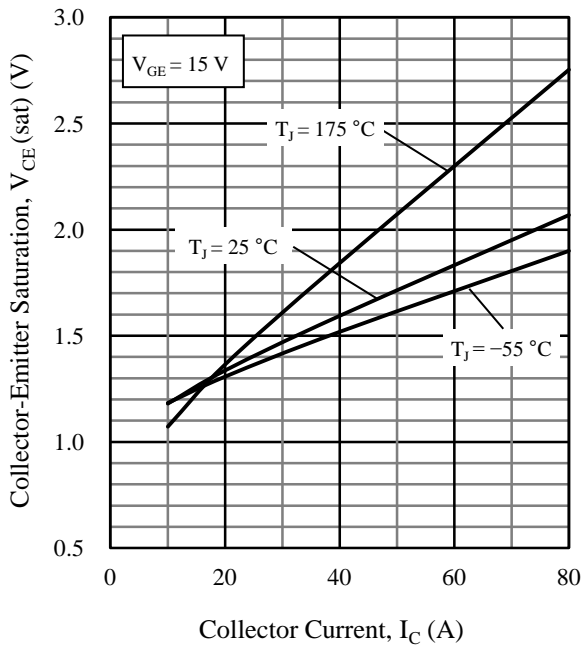


Figure 12. Saturation Voltage vs. Collector Current

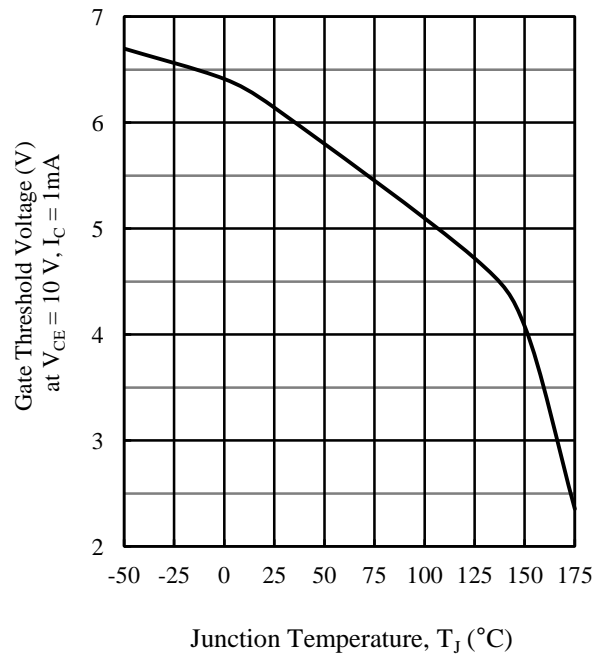


Figure 13. Gate Threshold Voltage vs. Junction Temperature

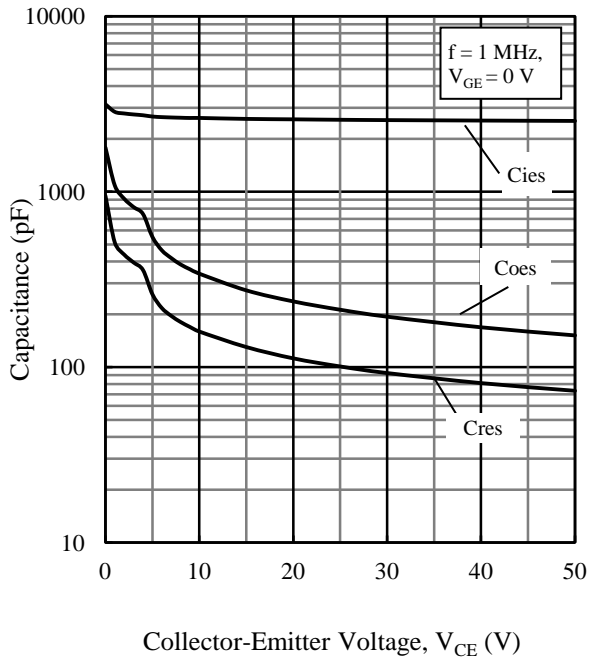


Figure 14. Capacitance Characteristics

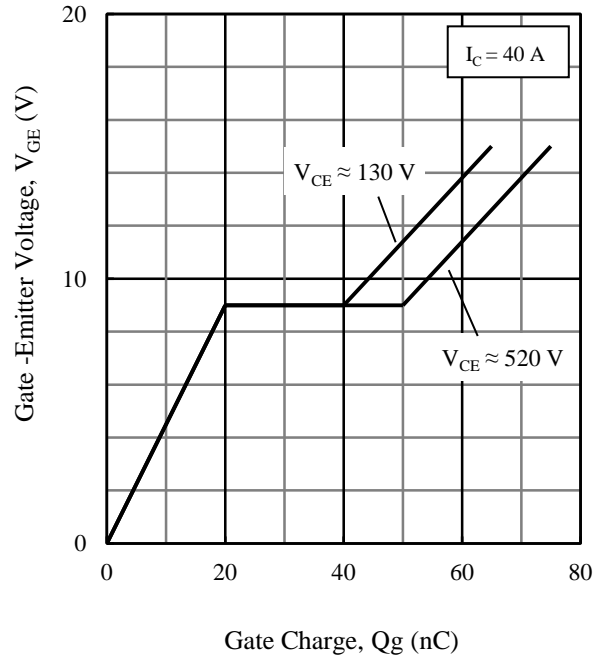


Figure 15. Typical Gate Charge

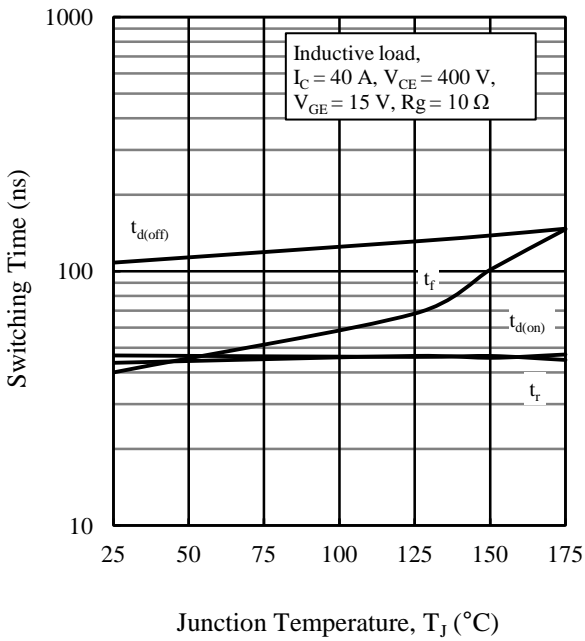


Figure 16. Switching Time vs. Junction Temperature

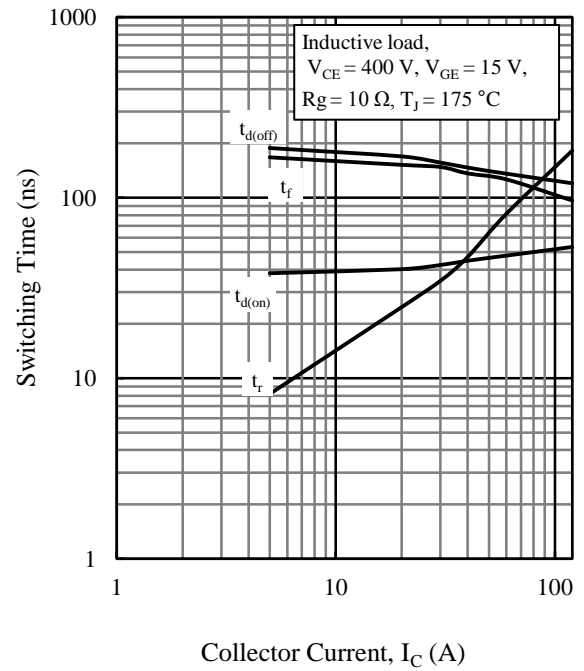


Figure 17. Switching Time vs. Collector Current



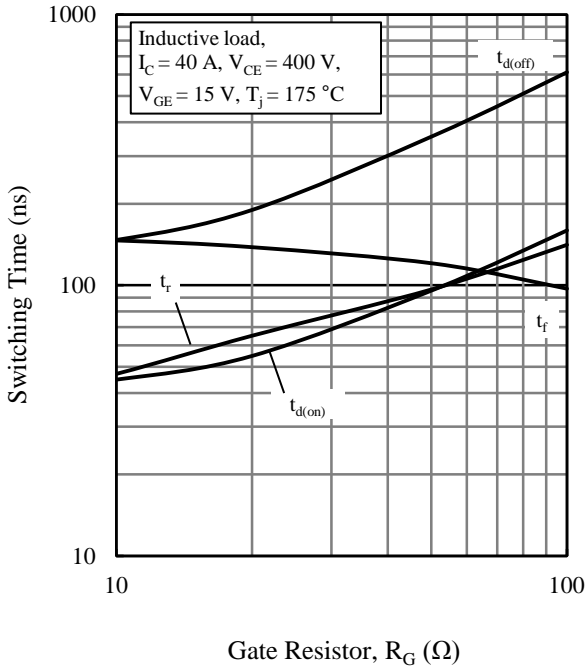


Figure 18. Switching Time vs. Gate Resistor

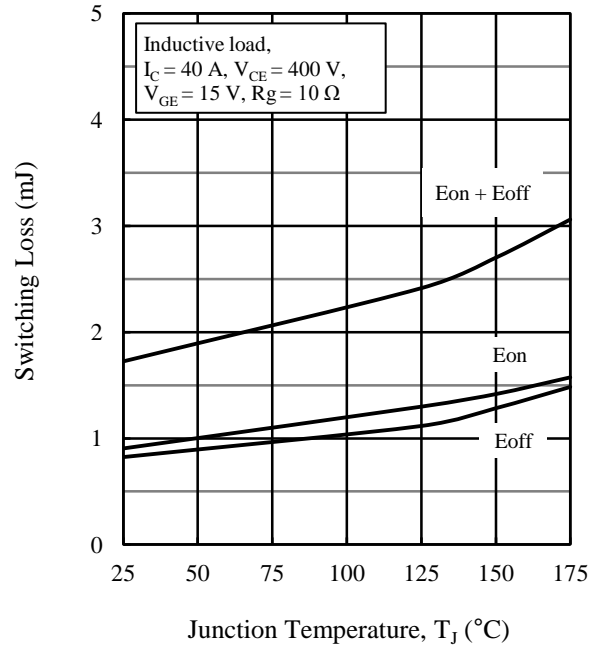


Figure 19. Switching Loss vs. Junction Temperature

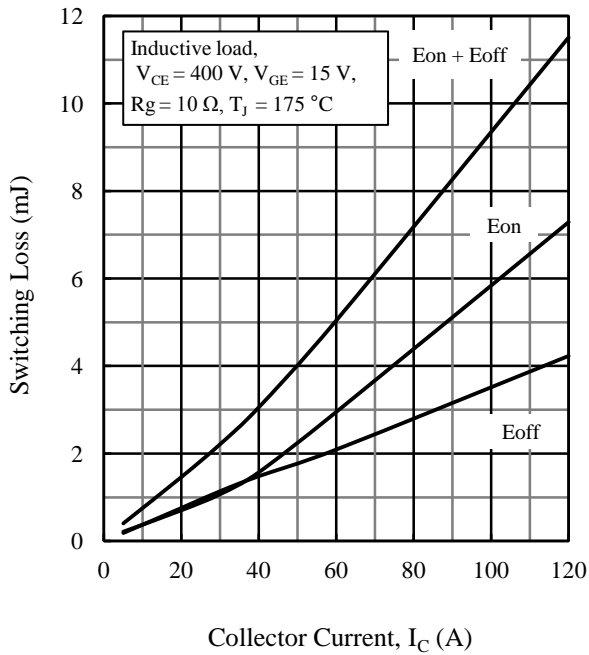


Figure 20. Switching Loss vs. Collector Current

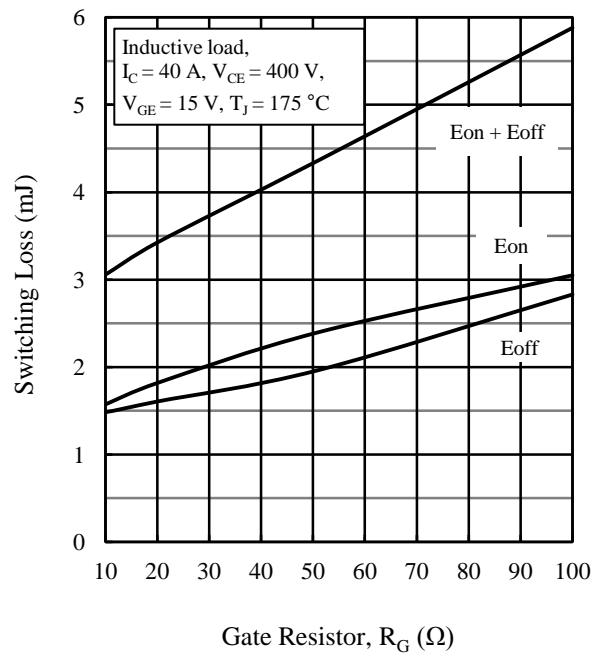


Figure 21. Switching Loss vs. Gate Resistor

**KGF65A4L, MGF65A4L, FGF65A4L**

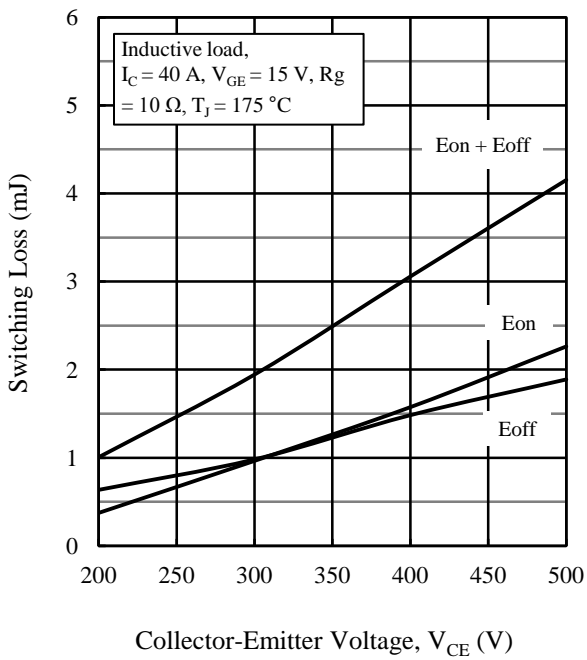


Figure 22. Switching Loss vs. Collector-Emitter Voltage

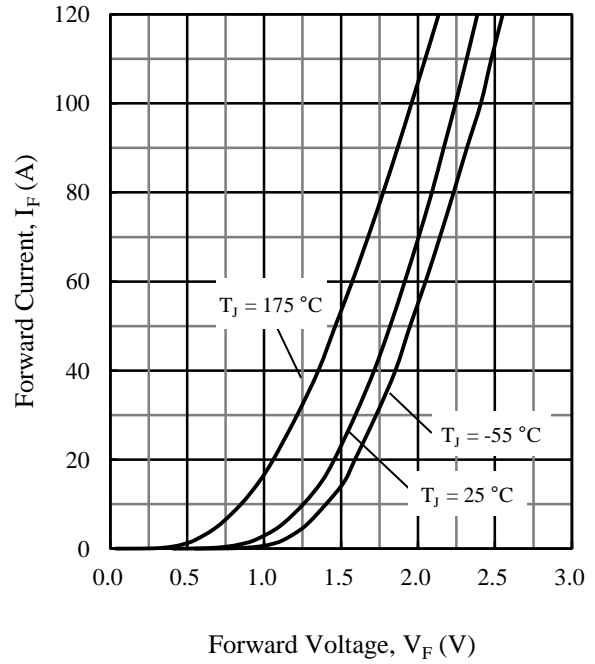


Figure 23. Diode Forward Characteristics

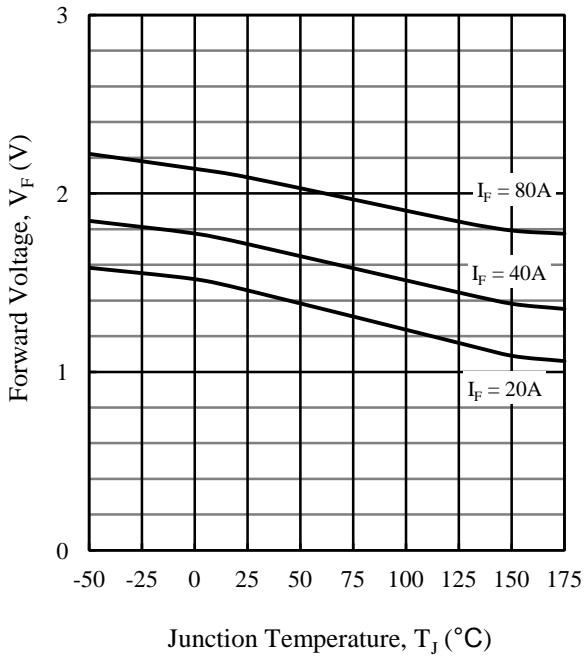


Figure 24. Diode Forward Voltage vs. Junction Temperature

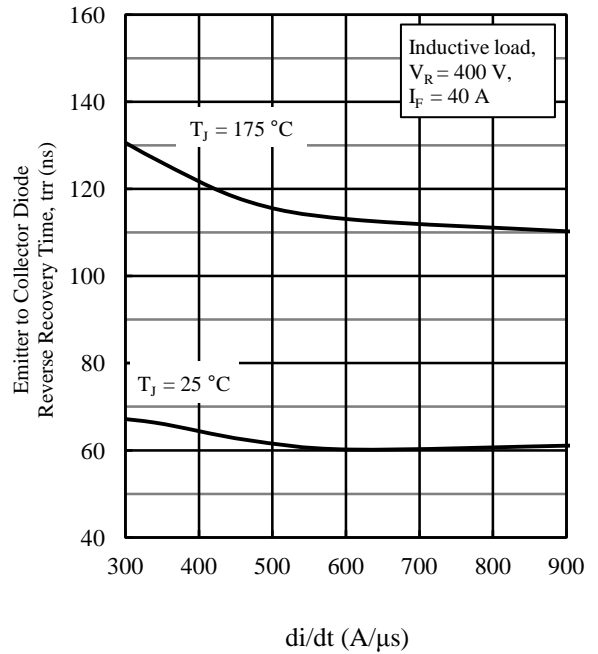


Figure 25. Emitter to Collector Diode Reverse Recovery Time vs. di/dt

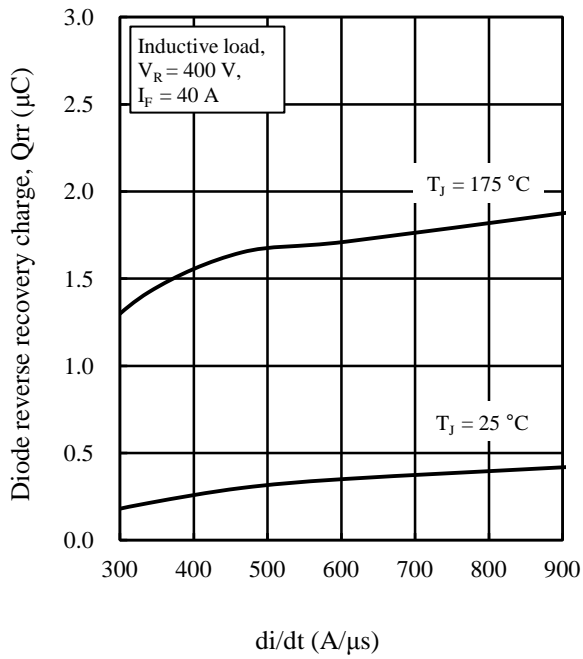


Figure 26. Diode Reverse Recovery Charge vs.  $di/dt$

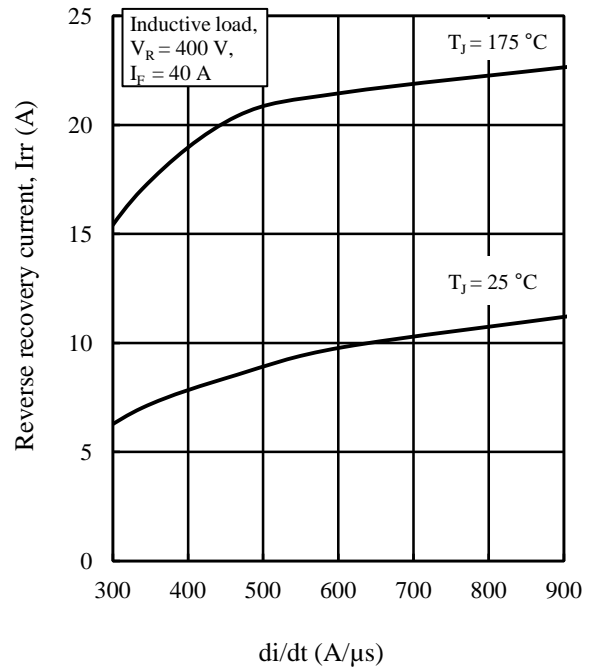


Figure 27. Recovery Current vs.  $di/dt$

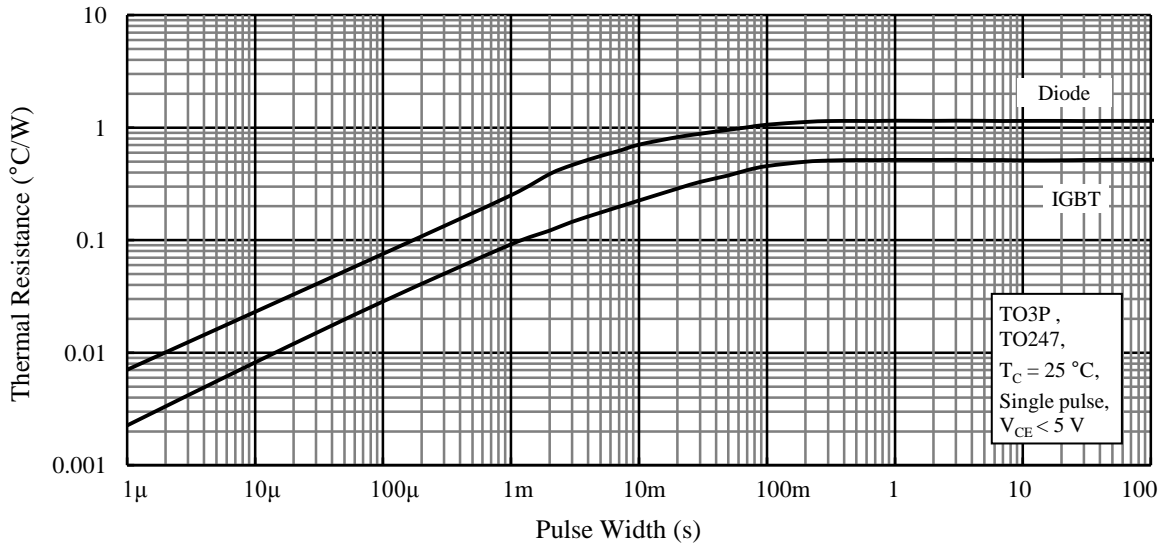


Figure 28. Transient Thermal Resistance

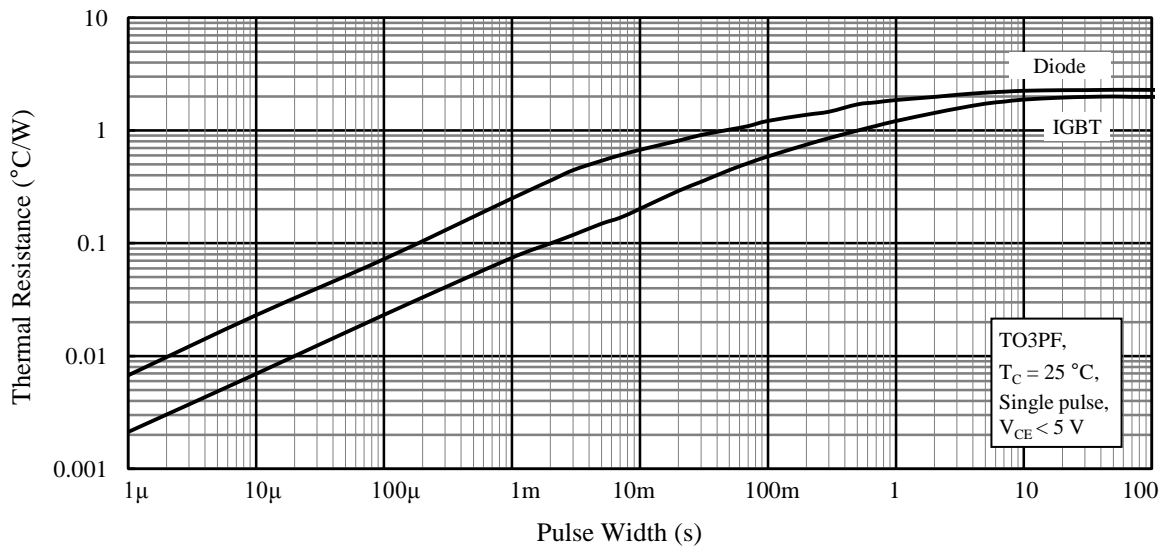
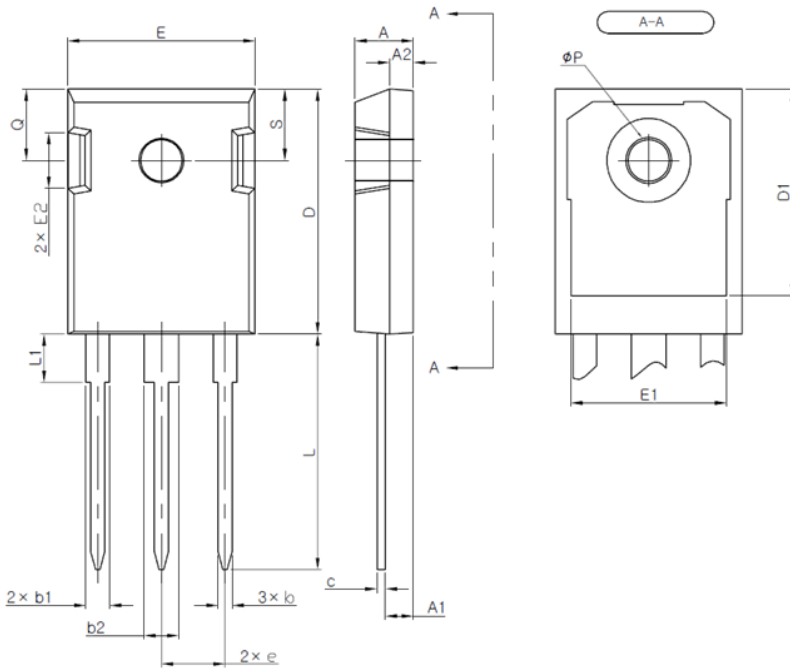


Figure 29. Transient Thermal Resistance

# KGF65A4L, MGF65A4L, FGF65A4L

## Physical Dimensions

### ● TO247-3L

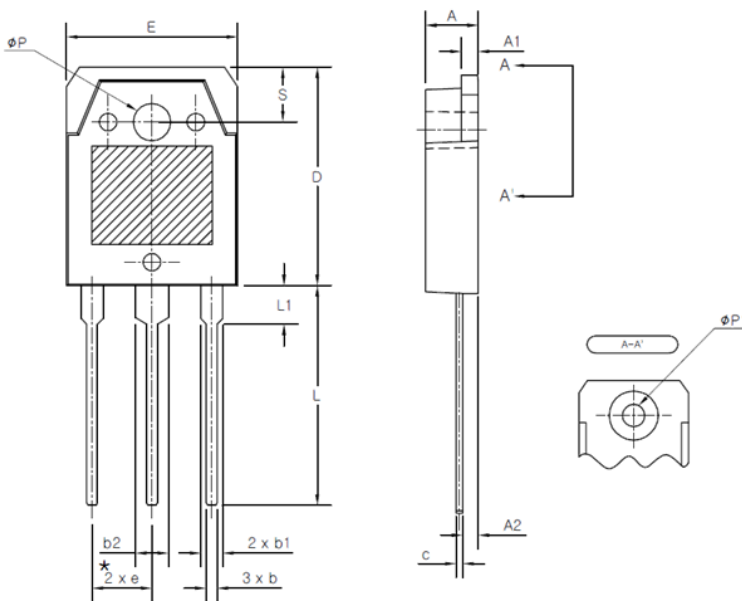


SYMBOL	MIN	NOM	MAX
A	4.83	5.02	5.21
A1	2.29	2.41	2.54
A2	1.91	2.04	2.16
b	1.14	1.27	1.40
b1	1.91	2.10	2.20
b2	2.92	3.10	3.20
c	0.61	0.71	0.80
D	20.80	21.07	21.34
D1	17.43	17.63	17.83
E	15.75	15.94	16.13
E1	13.06	13.26	13.46
E2	4.32	4.58	4.83
e	5.25	5.45	5.65
L	19.81	20.19	20.57
L1	3.81	4.07	4.32
φP	3.55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



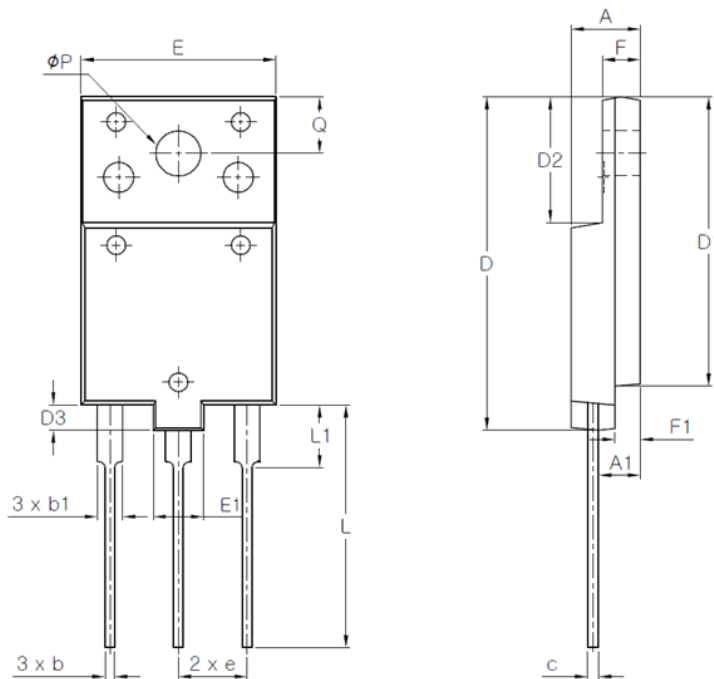
SYMBOL	MIN	NOM	MAX
A	4.60	4.80	5.00
A1	1.45	1.50	1.65
A2	1.20	1.40	1.60
b	0.80	1.00	1.20
b1	1.80	2.00	2.20
b2	2.80	3.00	3.20
c	0.55	0.60	0.75
D	19.70	19.90	20.10
E	15.40	15.60	15.80
*e	5.25	5.45	5.65
L	19.80	20.00	20.20
L1	3.30	3.50	3.70
φP	3.30	3.40	3.50
φP1	3.10	3.20	3.30
S	4.80	5.00	5.20

**NOTE**

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

# KGF65A4L, MGF65A4L, FGF65A4L

## • TO3PF-3L

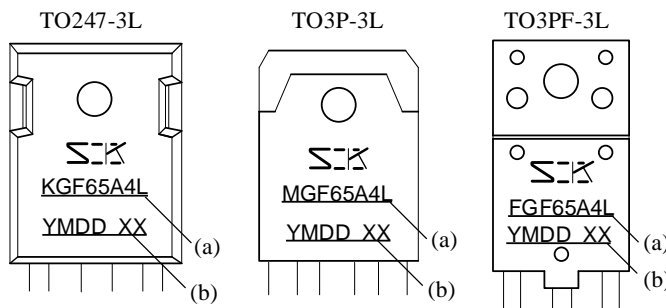


SYMBOL	MIN	NOM	MAX
A	5.30	5.50	5.70
A1	3.10	3.30	3.50
b	0.65	0.75	0.95
b1	1.80	2.00	2.20
c	0.80	0.90	1.10
D	26.30	26.50	26.70
D1	22.80	23.00	23.20
D2	9.80	10.00	10.20
D3	1.80	2.00	2.20
E	15.30	15.50	15.70
E1	3.80	4.00	4.20
e	5.25	5.45	5.65
F	2.80	3.00	3.20
F1	1.80	2.00	2.20
L	19.10	19.30	19.50
L1	4.80	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 for TO247, TO3P and TO3PF: Pb-free (RoHS compliant)
- When soldering the products, make sure to minimize the working time within the following limits:  
Flow:  $260 \pm 5 \text{ }^\circ\text{C} / 10 \pm 1 \text{ s}$ , 2 times  
Soldering Iron:  $380 \pm 10 \text{ }^\circ\text{C} / 3.5 \pm 0.5 \text{ s}$ , 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 to 0.882 N·m (7 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.

## Important Notes

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- No anti-radioactive ray design has been adopted for the Sanken Products.
- The circuit constant, operation examples, circuit examples, pattern layout examples, design examples, recommended examples, all information and evaluation results based thereon, etc., described in this document are presented for the sole purpose of reference of use of the Sanken Products.
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