

$V_{CES}$	650V
$I_{C(100^{\circ}C)}$	13A
$V_{CE(sat)} (Typ.)$	1.65V@ $I_C=25A$
$P_D$	47W

### ●Features

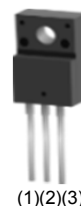
- 1) Low Collector - Emitter Saturation Voltage
- 2) Low Switching Loss
- 3) Short Circuit Withstand Time 5 $\mu$ s
- 4) Built in Very Fast & Soft Recovery FRD (RFN - Series)
- 5) Pb - free Lead Plating ; RoHS Compliant

### ●Applications

General Inverter  
UPS  
Power Conditioner  
Welder

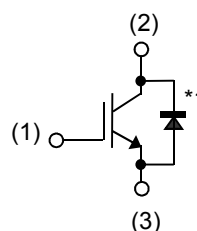
### ●Outline

TO-220NFM



(1)(2)(3)

### ●Inner Circuit



(1) Gate  
(2) Collector  
(3) Emitter

\*1 Built in FRD

### ●Packaging Specifications

Type	Packaging	Tube
	Reel Size (mm)	-
	Tape Width (mm)	-
	Basic Ordering Unit (pcs)	1,000
	Packing Code	C9
	Marking	RGT50TM65D

### ●Absolute Maximum Ratings (at $T_C = 25^{\circ}C$ unless otherwise specified)

Parameter		Symbol	Value	Unit
Collector - Emitter Voltage		$V_{CES}$	650	V
Gate - Emitter Voltage		$V_{GES}$	$\pm 30$	V
Collector Current	$T_C = 25^{\circ}C$	$I_C$	21	A
	$T_C = 100^{\circ}C$	$I_C$	13	A
Pulsed Collector Current		$I_{CP}^{*1}$	75	A
Diode Forward Current	$T_C = 25^{\circ}C$	$I_F$	22	A
	$T_C = 100^{\circ}C$	$I_F$	13	A
Diode Pulsed Forward Current		$I_{FP}^{*1}$	75	A
Power Dissipation	$T_C = 25^{\circ}C$	$P_D$	47	W
	$T_C = 100^{\circ}C$	$P_D$	23	W
Operating Junction Temperature		$T_j$	-40 to +175	$^{\circ}C$
Storage Temperature		$T_{stg}$	-55 to +175	$^{\circ}C$

\*1 Pulse width limited by  $T_{jmax}$ .

### ●Thermal Resistance

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Thermal Resistance IGBT Junction - Case	$R_{\theta(j-c)}$	-	-	3.19	°C/W
Thermal Resistance Diode Junction - Case	$R_{\theta(j-c)}$	-	-	4.47	°C/W

### ●IGBT Electrical Characteristics (at $T_j = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Collector - Emitter Breakdown Voltage	$BV_{CES}$	$I_C = 10\mu\text{A}$ , $V_{GE} = 0\text{V}$	650	-	-	V
Collector Cut - off Current	$I_{CES}$	$V_{CE} = 650\text{V}$ , $V_{GE} = 0\text{V}$	-	-	10	$\mu\text{A}$
Gate - Emitter Leakage Current	$I_{GES}$	$V_{GE} = \pm 30\text{V}$ , $V_{CE} = 0\text{V}$	-	-	$\pm 200$	nA
Gate - Emitter Threshold Voltage	$V_{GE(th)}$	$V_{CE} = 5\text{V}$ , $I_C = 17.5\text{mA}$	5.0	6.0	7.0	V
Collector - Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 25\text{A}$ , $V_{GE} = 15\text{V}$ $T_j = 25^\circ\text{C}$	-	1.65	2.1	V
		$T_j = 175^\circ\text{C}$	-	2.15	-	

**●IGBT Electrical Characteristics** (at  $T_j = 25^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Input Capacitance	$C_{ies}$	$V_{CE} = 30\text{V}$	-	1400	-	pF
Output Capacitance	$C_{oes}$	$V_{GE} = 0\text{V}$	-	56	-	
Reverse Transfer Capacitance	$C_{res}$	$f = 1\text{MHz}$	-	22	-	
Total Gate Charge	$Q_g$	$V_{CE} = 300\text{V}$	-	49	-	nC
Gate - Emitter Charge	$Q_{ge}$	$I_C = 25\text{A}$	-	15	-	
Gate - Collector Charge	$Q_{gc}$	$V_{GE} = 15\text{V}$	-	19	-	
Turn - on Delay Time	$t_{d(on)}$	$I_C = 25\text{A}, V_{CC} = 400\text{V}$	-	27	-	ns
Rise Time	$t_r$	$V_{GE} = 15\text{V}, R_G = 10\Omega$	-	32	-	
Turn - off Delay Time	$t_{d(off)}$	$T_j = 25^\circ\text{C}$	-	88	-	
Fall Time	$t_f$	Inductive Load	-	65	-	
Turn - on Delay Time	$t_{d(on)}$	$I_C = 25\text{A}, V_{CC} = 400\text{V}$	-	28	-	ns
Rise Time	$t_r$	$V_{GE} = 15\text{V}, R_G = 10\Omega$	-	37	-	
Turn - off Delay Time	$t_{d(off)}$	$T_j = 175^\circ\text{C}$	-	100	-	
Fall Time	$t_f$	Inductive Load	-	110	-	
Reverse Bias Safe Operating Area	RBSOA	$I_C = 75\text{A}, V_{CC} = 520\text{V}$ $V_P = 650\text{V}, V_{GE} = 15\text{V}$ $R_G = 50\Omega, T_j = 175^\circ\text{C}$	FULL SQUARE			-
Short Circuit Withstand Time	$t_{sc}$	$V_{CC} \leq 360\text{V}$ $V_{GE} = 15\text{V}$ $T_j = 25^\circ\text{C}$	5	-	-	$\mu\text{s}$

**●FRD Electrical Characteristics** (at  $T_j = 25^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Diode Forward Voltage	$V_F$	$I_F = 20\text{A}$ $T_j = 25^\circ\text{C}$ $T_j = 175^\circ\text{C}$	- -	1.45 1.25	1.9 -	V
Diode Reverse Recovery Time	$t_{rr}$	$I_F = 20\text{A}$ $V_{CC} = 400\text{V}$ $di_F/dt = 200\text{A}/\mu\text{s}$ $T_j = 25^\circ\text{C}$	-	58	-	ns
Diode Peak Reverse Recovery Current	$I_{rr}$		-	6.3	-	A
Diode Reverse Recovery Charge	$Q_{rr}$		-	0.20	-	$\mu\text{C}$
Diode Reverse Recovery Time	$t_{rr}$		-	256	-	ns
Diode Peak Reverse Recovery Current	$I_{rr}$	$V_{CC} = 400\text{V}$ $di_F/dt = 200\text{A}/\mu\text{s}$ $T_j = 175^\circ\text{C}$	-	10.4	-	A
Diode Reverse Recovery Charge	$Q_{rr}$		-	1.35	-	$\mu\text{C}$

●Electrical Characteristic Curves

Fig.1 Power Dissipation vs. Case Temperature

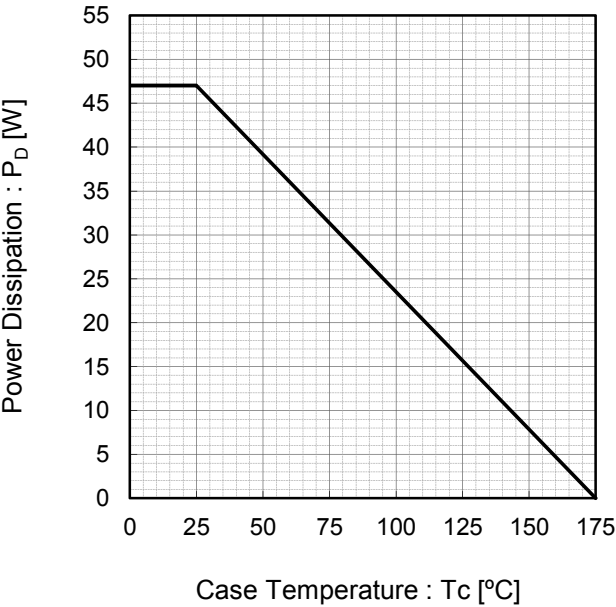


Fig.2 Collector Current vs. Case Temperature

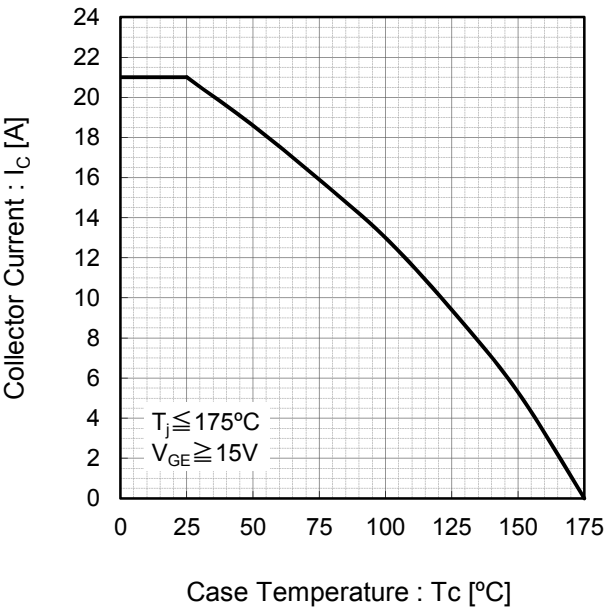


Fig.3 Forward Bias Safe Operating Area

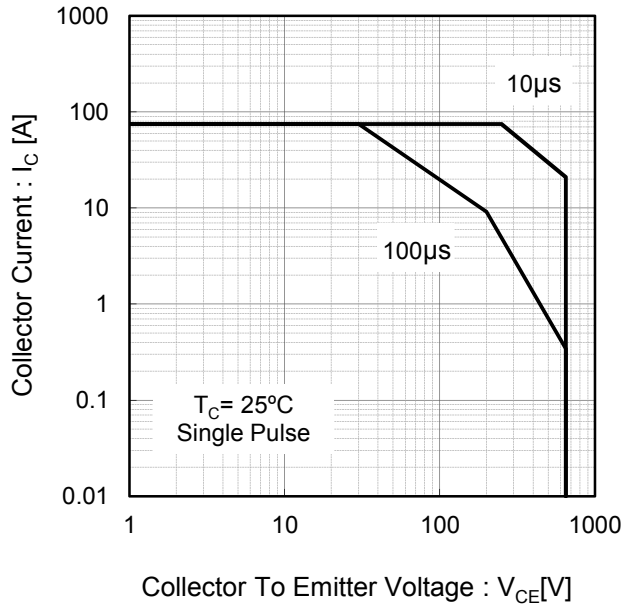
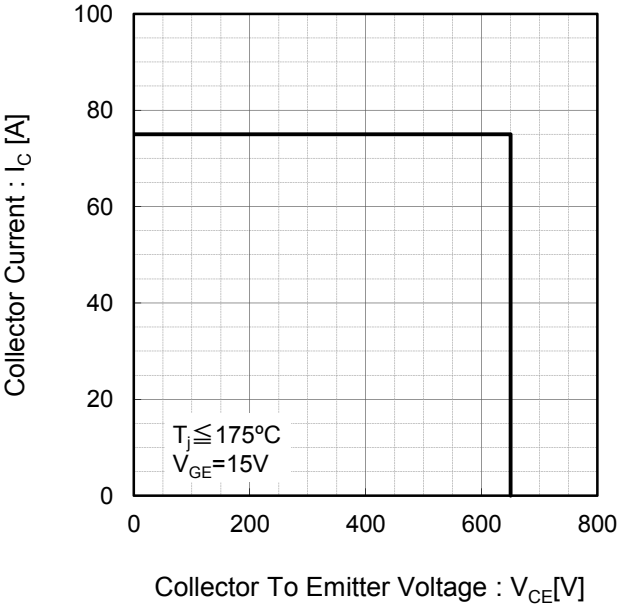


Fig.4 Reverse Bias Safe Operating Area



●Electrical Characteristic Curves

Fig.5 Typical Output Characteristics

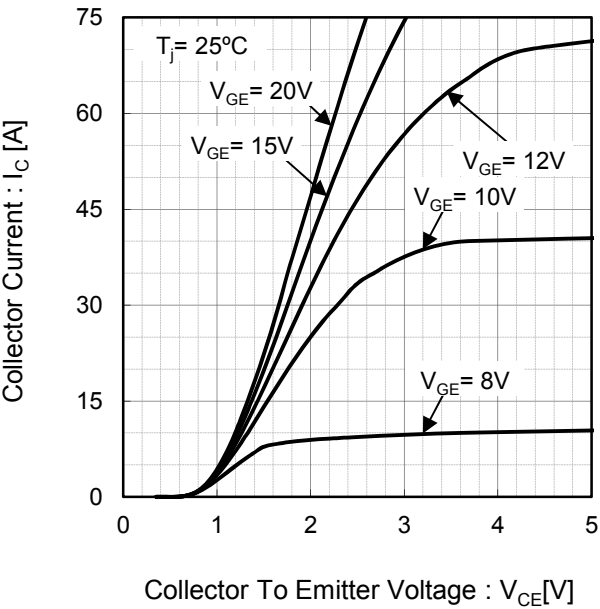


Fig.6 Typical Output Characteristics

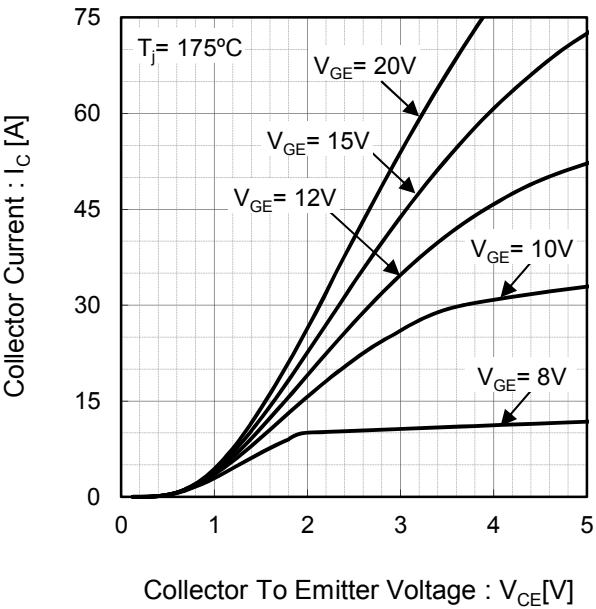


Fig.7 Typical Transfer Characteristics

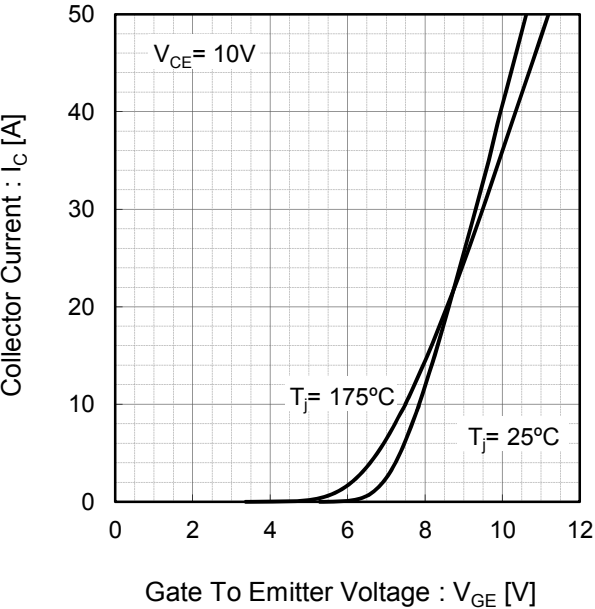
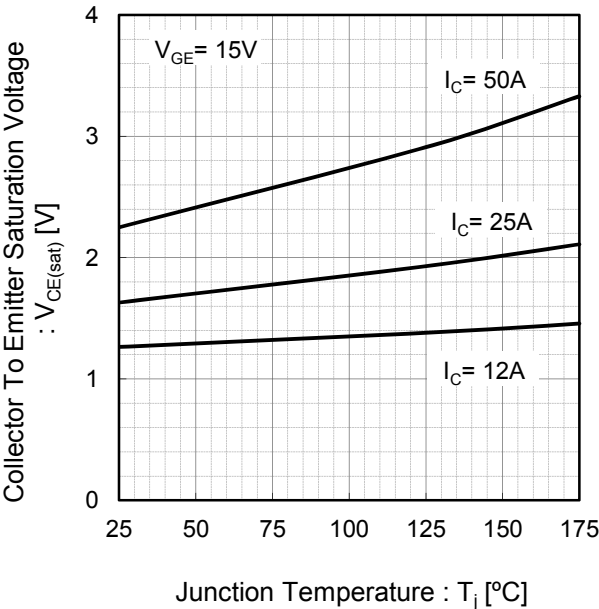


Fig.8 Typical Collector To Emitter Saturation Voltage vs. Junction Temperature



●Electrical Characteristic Curves

Fig.9 Typical Collector To Emitter Saturation Voltage vs. Gate To Emitter Voltage

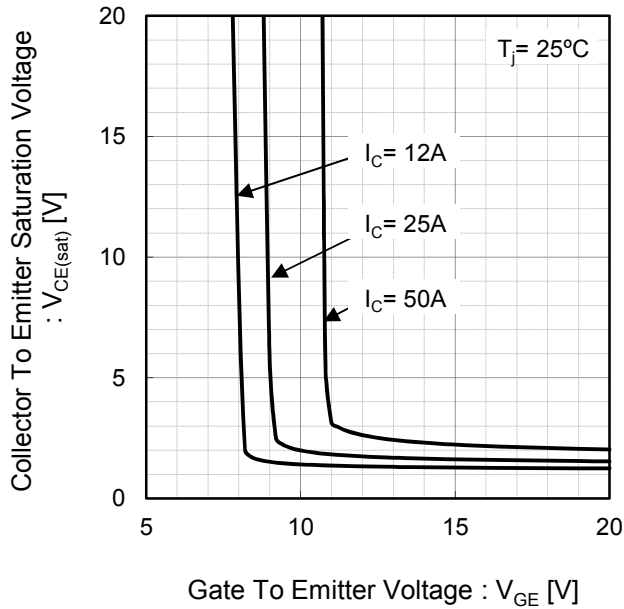


Fig.10 Typical Collector To Emitter Saturation Voltage vs. Gate To Emitter Voltage

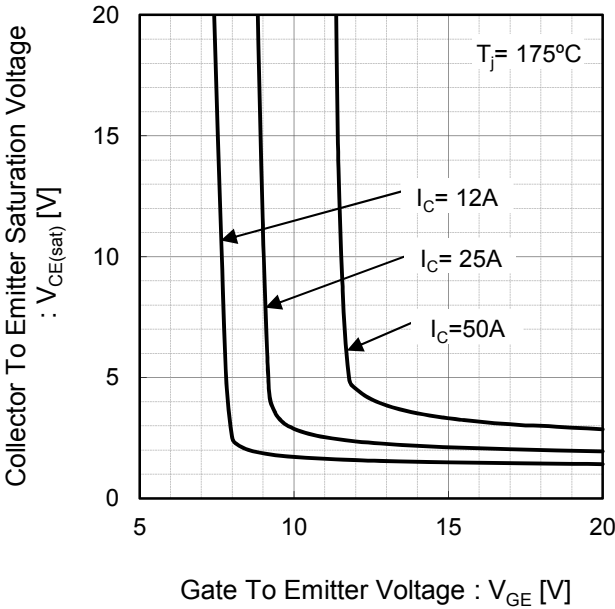


Fig.11 Typical Switching Time vs. Collector Current

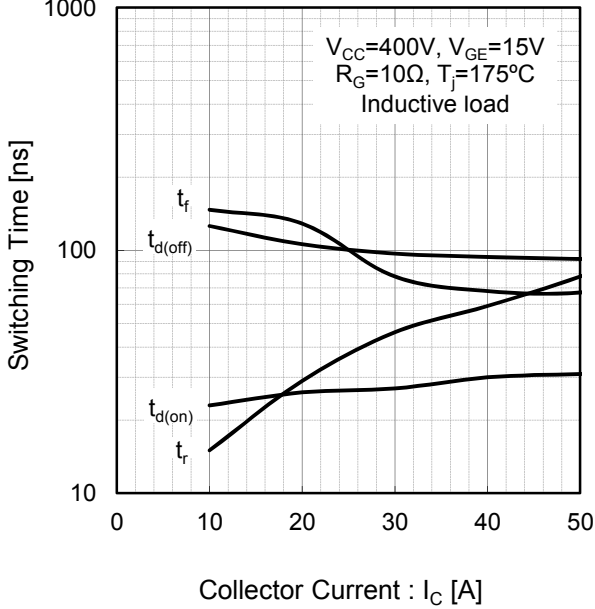
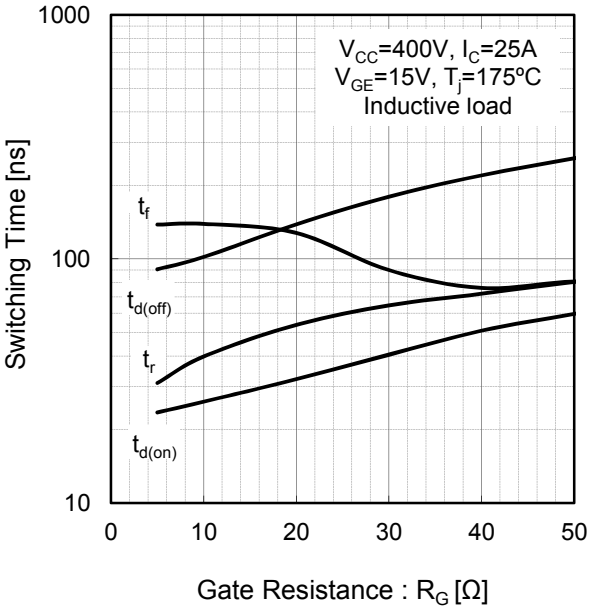


Fig.12 Typical Switching Time vs. Gate Resistance



●Electrical Characteristic Curves

Fig.13 Typical Switching Energy Losses vs. Collector Current

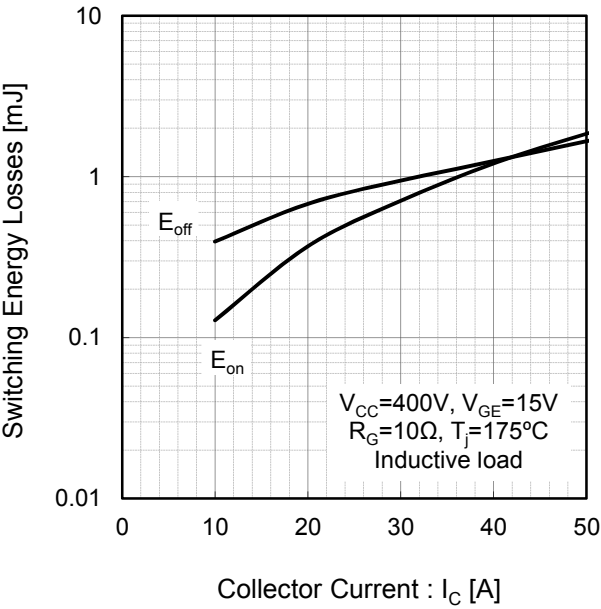


Fig.14 Typical Switching Energy Losses vs. Gate Resistance

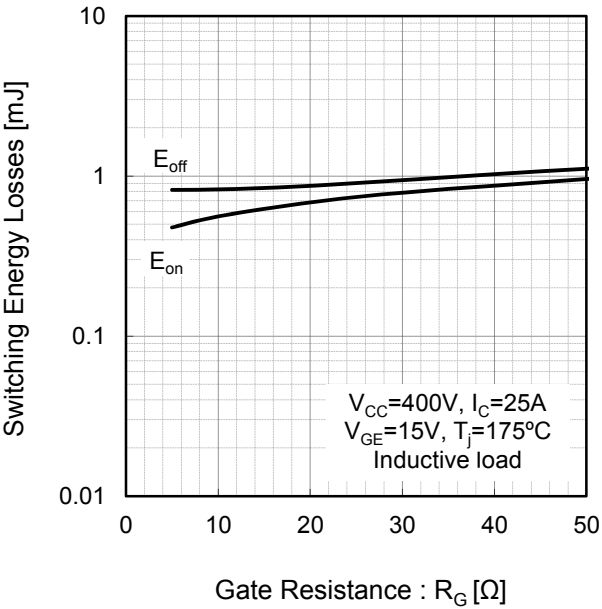


Fig.15 Typical Capacitance vs. Collector To Emitter Voltage

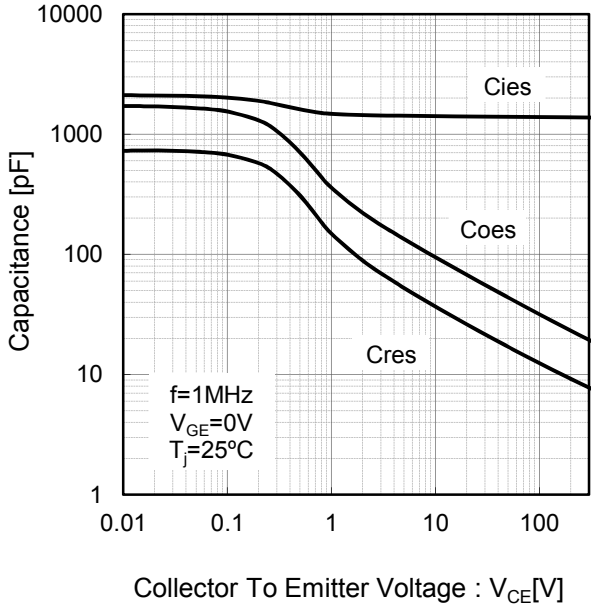
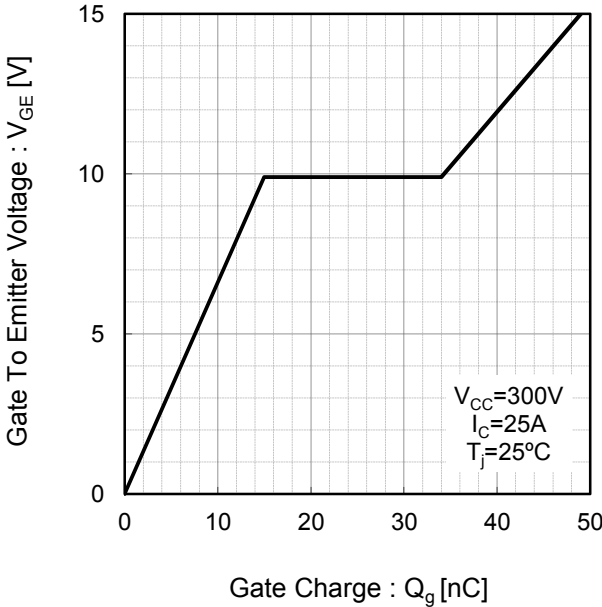


Fig.16 Typical Gate Charge



●Electrical Characteristic Curves

Fig.17 Typical Diode Forward Current vs. Forward Voltage

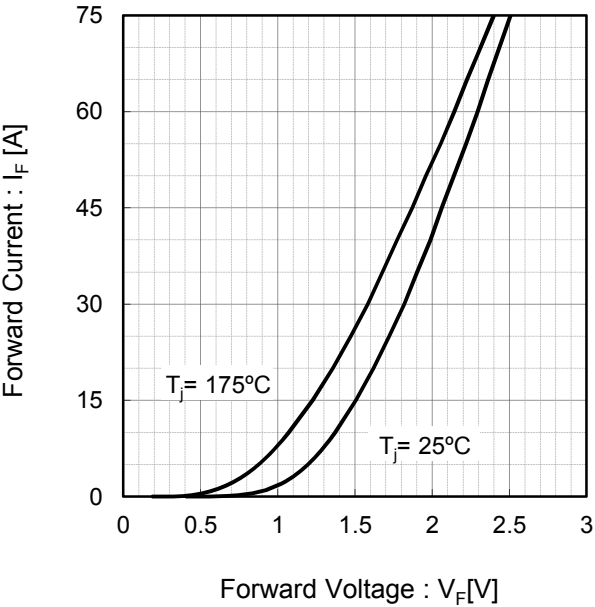


Fig.18 Typical Diode Reverse Recovery Time vs. Forward Current

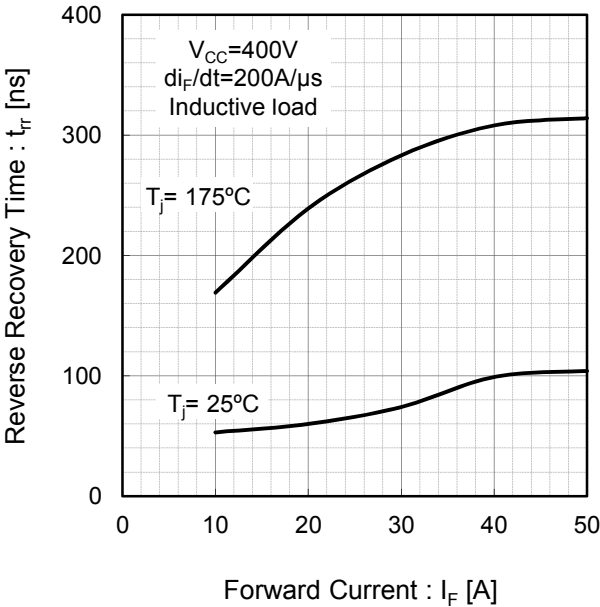


Fig.19 Typical Diode Reverse Recovery Current vs. Forward Current

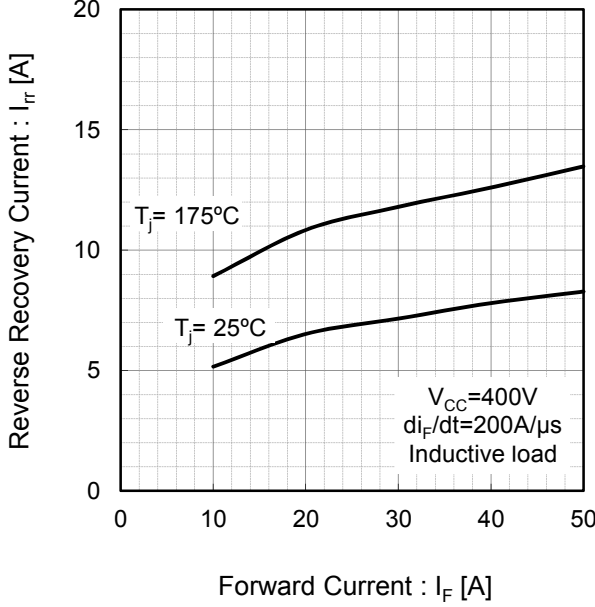
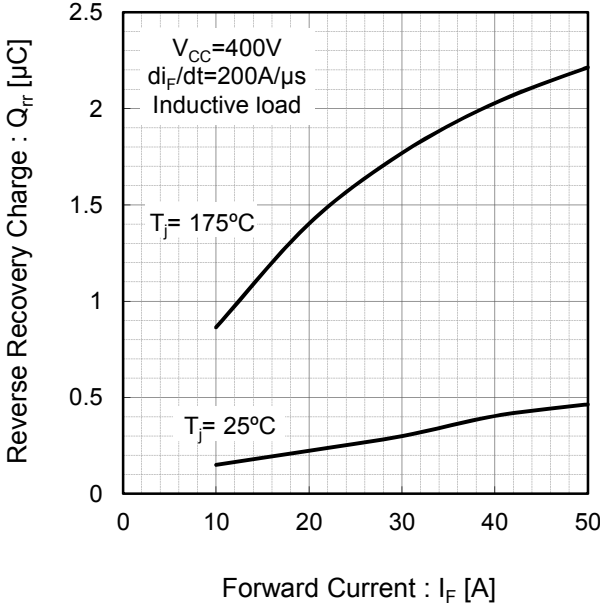


Fig.20 Typical Diode Reverse Recovery Charge vs. Forward Current



●Electrical Characteristic Curves

Fig.21 IGBT Transient Thermal Impedance

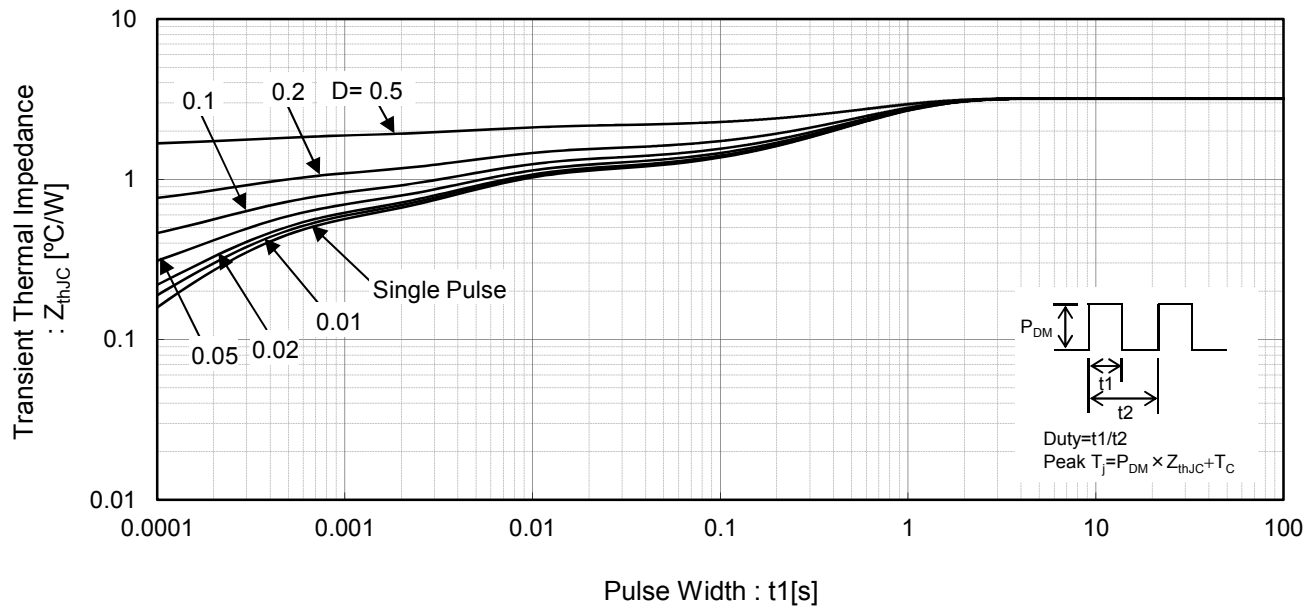
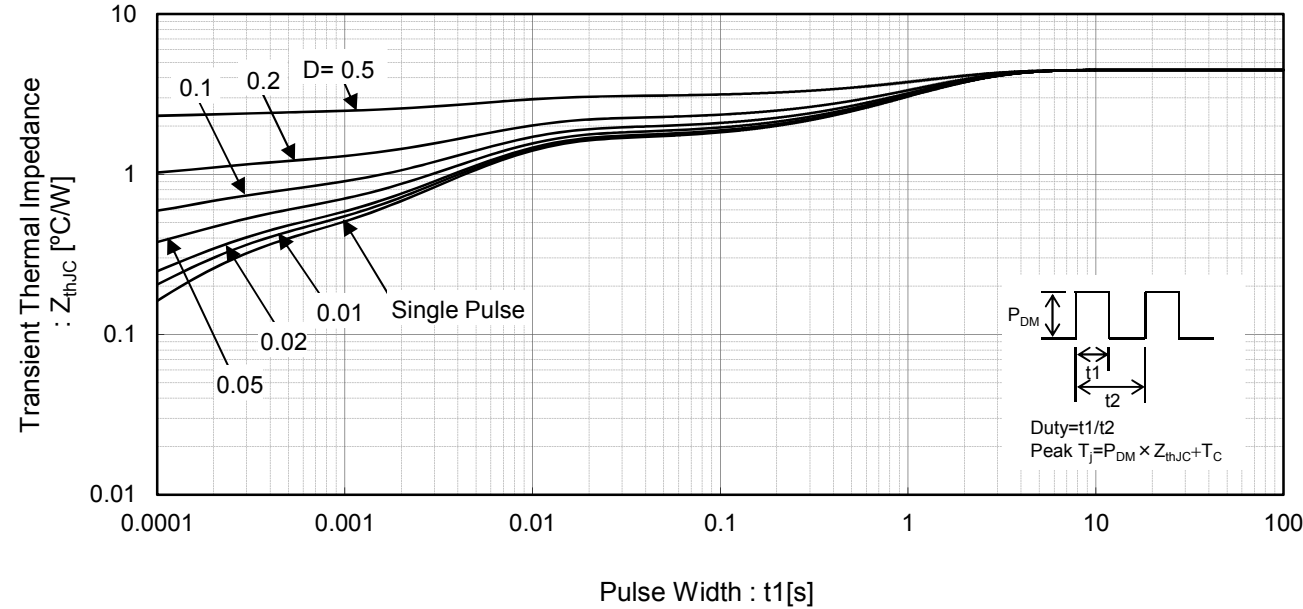


Fig.22 Diode Transient Thermal Impedance



●Inductive Load Switching Circuit and Waveform

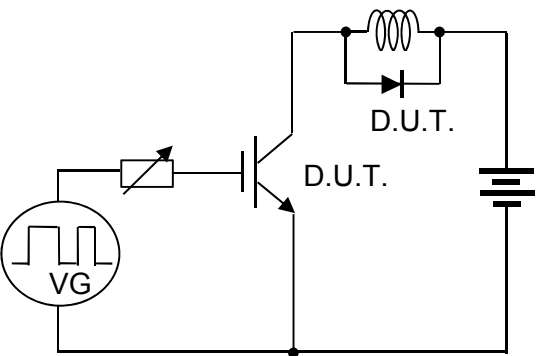


Fig.23 Inductive Load Circuit

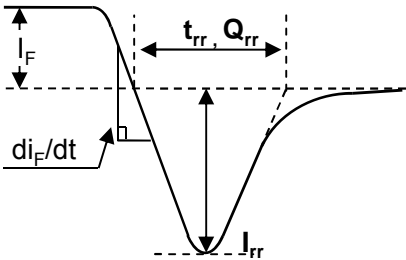


Fig.25 Diode Reverse Recovery Waveform

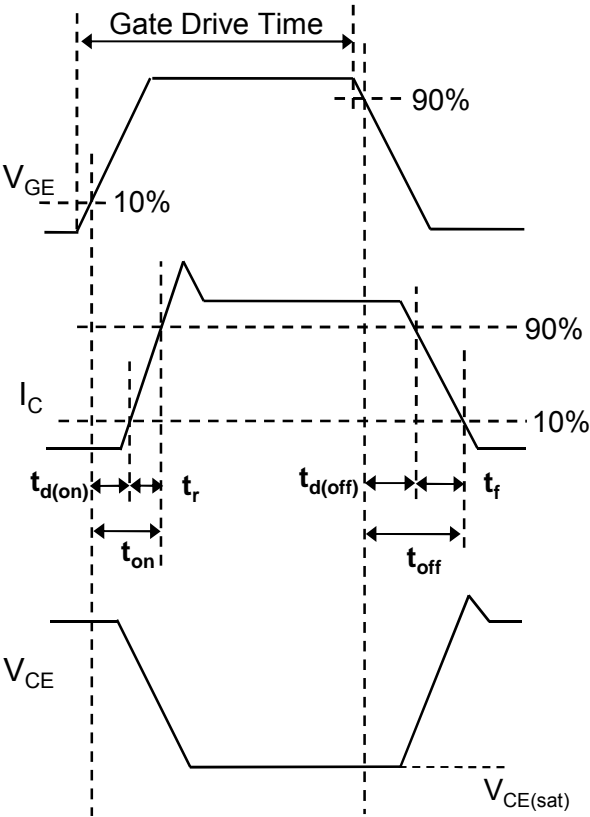


Fig.24 Inductive Load Waveform

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