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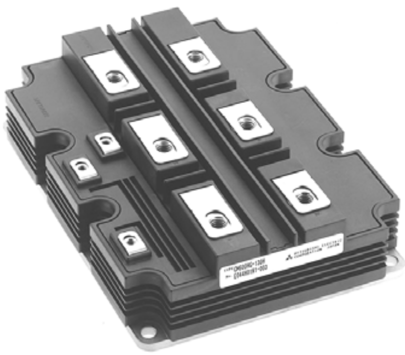
Date	I.Umezaki 24-Feb.-2009	

CM400E4G-130H

HIGH POWER SWITCHING USE
INSULATED TYPE

3[th]-Version HVIGBT (High Voltage Insulated Gate Bipolar Transistor) Modules

CM400E4G-130H



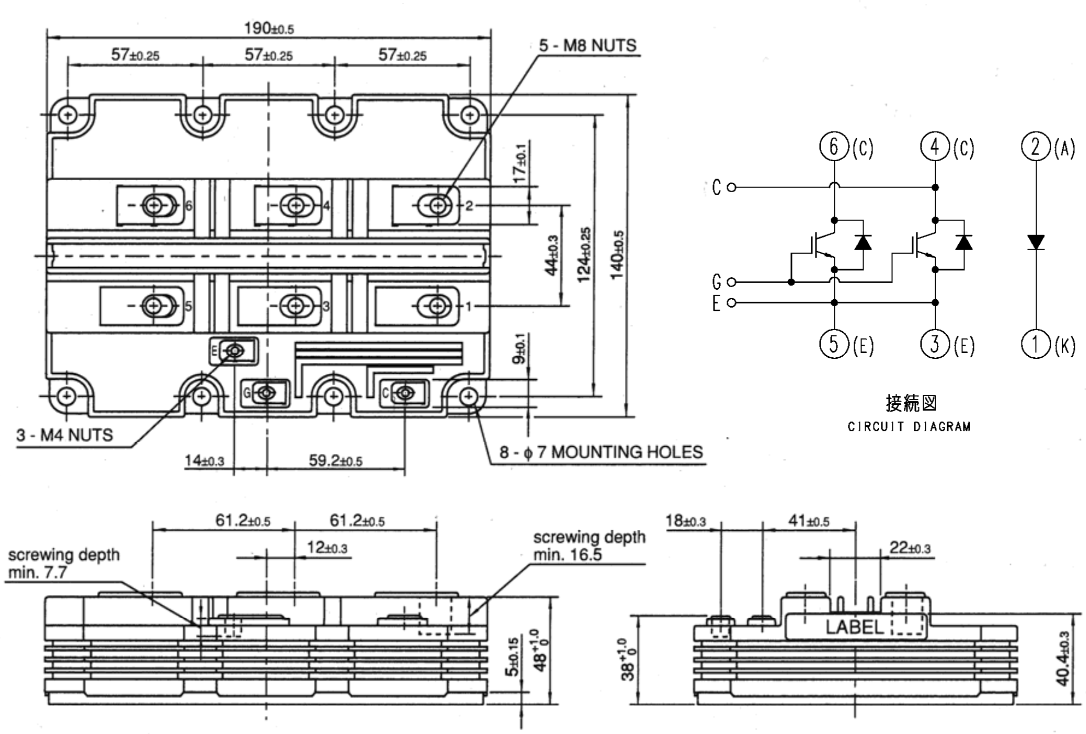
- I_C .... 400 A
- V_{CES} .... 6500 V
- 1-element in a Pack (for brake chopper)
- Insulated Type
- AlSiC Baseplate

APPLICATION

Traction drives, High Reliability Converters / Inverters, DC choppers

OUTLINE DRAWING & CIRCUIT DIAGRAM

Dimensions in mm



MAXIMUM RATINGS

Symbol	Item	Conditions		Ratings	Unit
V_{CES}	Collector-emitter voltage	V_{GE} = 0 V	T_j = -40 °C	5800	V
			T_j = +25 °C	6300	
			T_j = +125 °C	6500	
V_{GES}	Gate-emitter voltage	V_{CE} = 0V, T_j = 25°C		± 20	V
I_C	Collector current	DC, T_c = 80°C		400	A
I_{CM}		Pulse (Note 1)		800	A
I_E	Emitter current (Note 2)	DC		400	A
I_{EM}		Pulse (Note 1)		800	A
P_c	Maximum power dissipation (Note 3)	T_c = 25°C, IGBT part		5900	W
V_{iso}	Isolation voltage	RMS, sinusoidal, f = 60Hz, t = 1 min.		10200	V
V_e	Partial discharge extinction voltage	RMS, sinusoidal, f = 60Hz, Q_{PD} ≤ 10 pC		5100	V
T_j	Junction temperature			−40 ~ +150	°C
T_{op}	Operating temperature			−40 ~ +125	°C
T_{stg}	Storage temperature			−40 ~ +125	°C
t_{psc}	Maximum short circuit pulse width	V_{CC} =4500V, V_{CE} ≤ V_{CES}, V_{GE} =15V, T_j =125°C		10	μs

ELECTRICAL CHARACTERISTICS

Symbol	Item	Conditions		Limits			Unit
				Min	Typ	Max	
I_{CES}	Collector cutoff current	V_{CE} = V_{CES}, V_{GE} = 0V	T_j = 25°C	—	—	7	mA
			T_j = 125°C	—	20	60	
$V_{GE(th)}$	Gate-emitter threshold voltage	V_{CE} = 10 V, I_C = 40 mA, T_j = 25°C		5.0	6.0	7.0	V
I_{GES}	Gate leakage current	V_{GE} = V_{GES}, V_{CE} = 0V, T_j = 25°C		−0.5	—	0.5	μA
C_{ies}	Input capacitance	V_{CE} = 10 V, V_{GE} = 0 V, f = 100 kHz, T_j = 25°C		—	82.0	—	nF
C_{oes}	Output capacitance			—	5.0	—	nF
C_{res}	Reverse transfer capacitance			—	1.4	—	nF
Q_g	Total gate charge	V_{CC} = 3600 V, I_C = 400 A, V_{GE} = ±15 V, T_j = 25 °C		—	6.6	—	μC
$V_{CE(sat)}$	Collector-emitter saturation voltage	I_C = 400 A (Note 4), V_{GE} = 15 V	T_j = 25°C	—	4.5	—	V
			T_j = 125°C	—	4.6	—	
$t_{d(on)}$	Turn-on delay time	V_{CC} = 3600 V, I_C = 400 A, V_{GE} = ±15 V, $R_{G(on)}$ = 15 Ω, T_j = 125 °C, L_s = 170 nH, $t_{(IGBT\_off)}$ = 60 μs (Note 6), Inductive load		—	1.2	—	μs
t_r	Turn-on rise time			—	0.35	—	μs
$E_{on(10\%)}$	Turn-on switching energy (Note 5)			—	3.0	—	J/P
$t_{d(off)}$	Turn-off delay time	V_{CC} = 3600 V, I_C = 400 A, V_{GE} = ±15 V, $R_{G(off)}$ = 50 Ω, T_j = 125 °C, L_s = 170 nH, Inductive load		—	8.2	—	μs
t_f	Turn-off fall time			—	0.5	—	μs
t_{f2}	Turn-off fall time			—	3.1	—	μs
$E_{off(10\%)}$	Turn-off switching energy (Note 5)			—	2.7	—	J/P
V_{EC}	Emitter-collector voltage (Note 2)	I_E = 400 A (Note 4), V_{GE} = 0 V	T_j = 25 °C	—	4.0	—	V
			T_j = 125 °C	—	3.6	—	
t_{rr}	Reverse recovery time (Note 2)	V_{CC} = 3600 V, I_E = 400 A, V_{GE} = ±15 V, $R_{G(on)}$ = 15 Ω, T_j = 125 °C, L_s = 170 nH, $t_{(IGBT\_off)}$ = 60 μs (Note 6), Inductive load		—	1.0	—	μs
t_{rr2}	Reverse recovery time (Note 2)			—	2.4	—	μs
Q_{rr}	Reverse recovery charge (Note 2)			—	740	—	μC
$E_{rec(10\%)}$	Reverse recovery energy (Note 2), (Note 5)			—	1.4	—	J/P

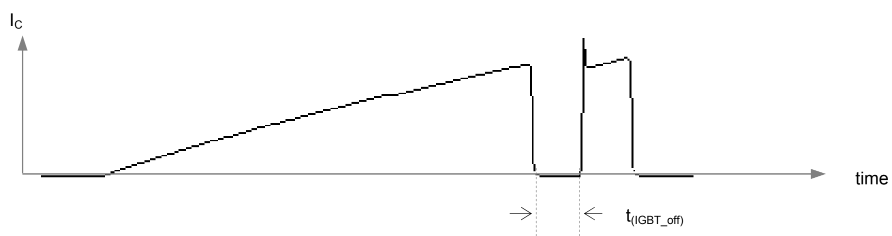
THERMAL CHARACTERISTICS

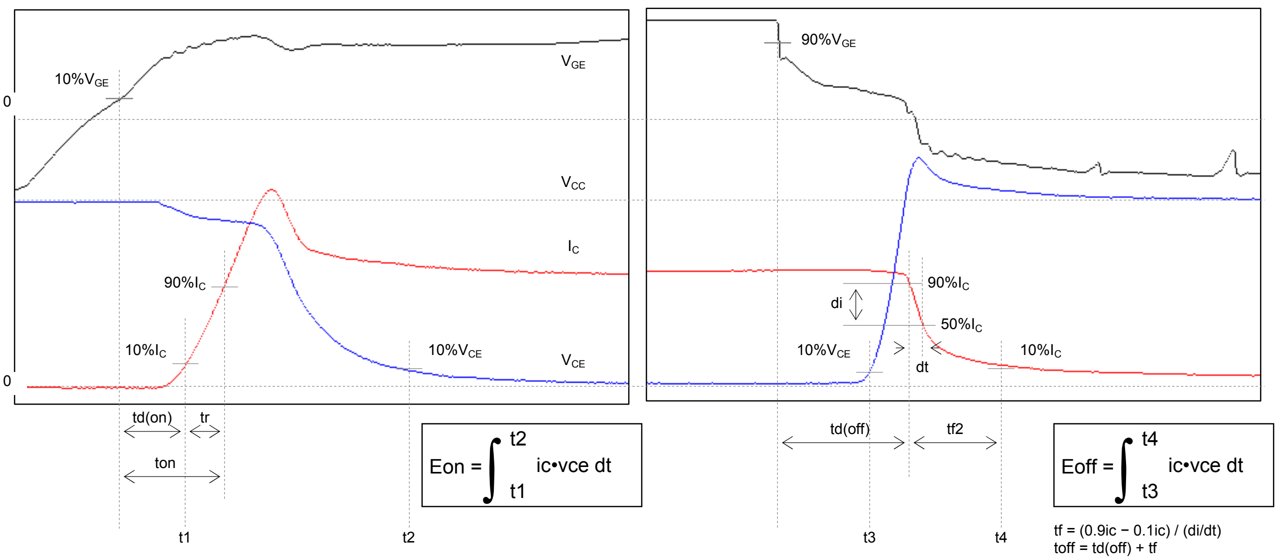
Symbol	Item	Conditions	Limits			Unit
			Min	Typ	Max	
$R_{th(j-c)Q}$	Thermal resistance	Junction to Case, IGBT part	—	—	21.0	K/kW
$R_{th(j-c)R}$	Thermal resistance	Junction to Case, FWDi part	—	—	33.0	K/kW
		Junction to Case, Clamp-Di part	—	—	33.0	K/kW
$R_{th(c-f)}$	Contact thermal resistance	Case to Fin, λ_{grease} = 1W/m·K, $D_{(c-f)}$ = 100 μm	—	9.0	—	K/kW

MECHANICAL CHARACTERISTICS

Symbol	Item	Conditions	Limits			Unit
			Min	Typ	Max	
M_t	Mounting torque	M8: Main terminals screw	7.0	—	15.0	N·m
M_s		M6: Mounting screw	3.0	—	6.0	N·m
M_t		M4: Auxiliary terminals screw	1.0	—	3.0	N·m
m	Mass		—	1.35	—	kg
CTI	Comparative tracking index		600	—	—	—
d_a	Clearance		26.0	—	—	mm
d_s	Creepage distance		56.0	—	—	mm
$L_{P\ CE}$	Parasitic stray inductance	Collector to Emitter	—	27.0	—	nH
		Anode to Cathode	—	54.0	—	nH
$R_{CC'+EE'}$	Internal lead resistance	T_c = 25°C, Collector to Emitter	—	0.19	—	mΩ
		T_c = 25°C, Anode to Cathode	—	0.38	—	mΩ

Note 1. Pulse width and repetition rate should be such that junction temperature (T_j) does not exceed T_{opmax} rating (125°C).
Note 2. The symbols represent characteristics of the anti-parallel, emitter to collector free-wheel diode (FWDi) and the brake chopper, anode to cathode clamp diode (Clamp-Di).
Note 3. Junction temperature (T_j) should not exceed T_{jmax} rating (150°C).
Note 4. Pulse width and repetition rate should be such as to cause negligible temperature rise.
Note 5. $E_{on(10\%)}$ / $E_{off(10\%)}$ / $E_{rec(10\%)}$ are the integral of $0.1V_{CE} \times 0.1I_C \times dt$.
Note 6. $t_{(IGBT\_off)}$ definition is shown as follows.



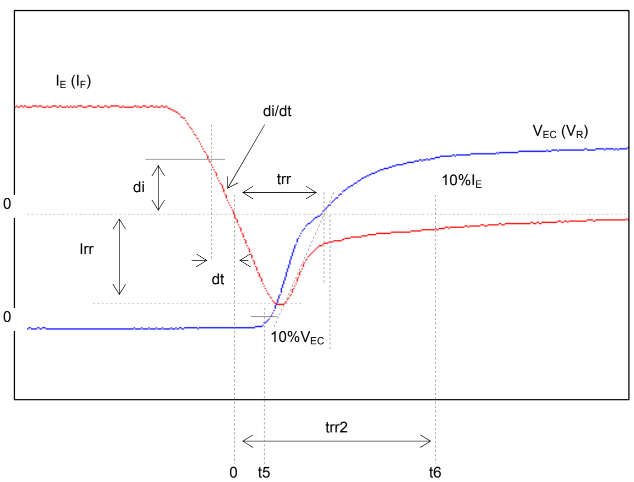


$$E_{on} = \int_{t1}^{t2} ic \bullet vce \, dt$$

$$E_{off} = \int_{t3}^{t4} ic \bullet vce \, dt$$

tf = (0.9ic − 0.1ic) / (di/dt)
toff = td(off) + tf

Fig. 2 – Definitions of switching times & energies of IGBT part



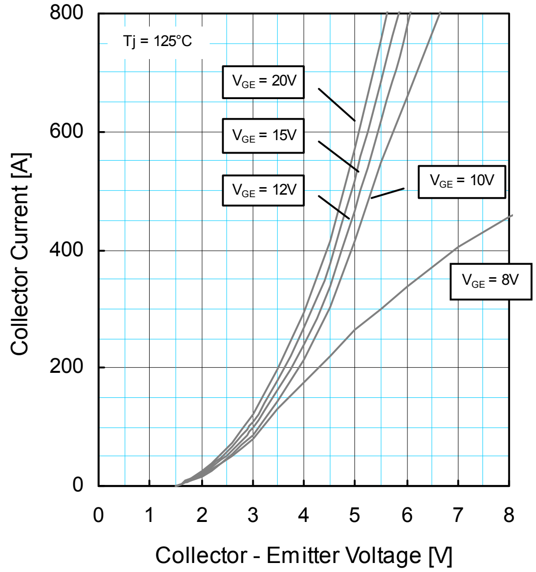
$$Q_{rr} = -\int_{0}^{t6} ie \, dt$$

$$E_{rec} = -\int_{t5}^{t6} ie \bullet vec \, dt$$

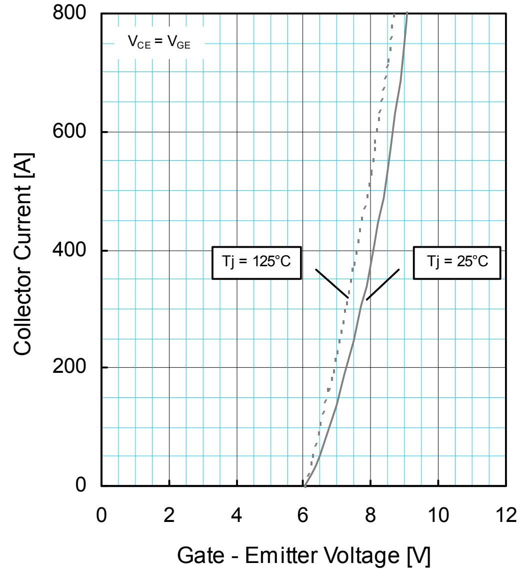
Fig. 3 – Definitions of reverse recovery charge & energy of FWDi part

PERFORMANCE CURVES

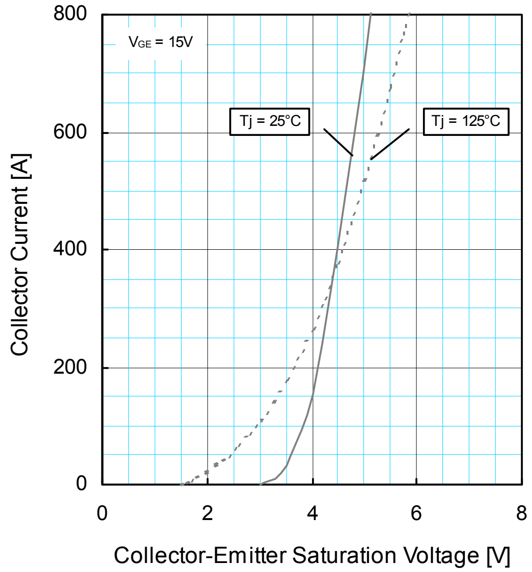
OUTPUT CHARACTERISTICS (TYPICAL)



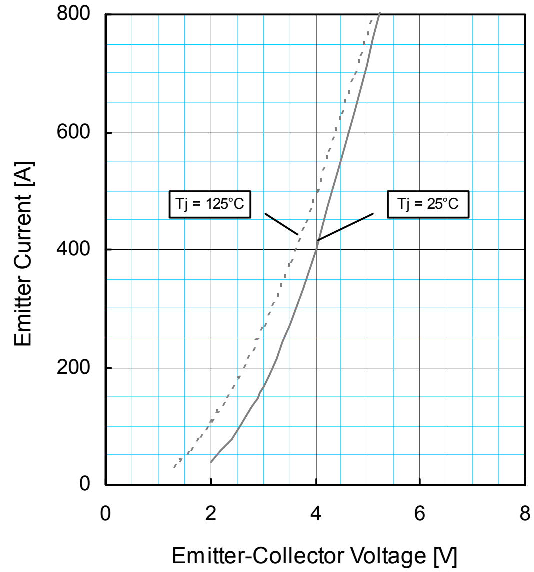
TRANSFER CHARACTERISTICS (TYPICAL)



COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS (TYPICAL)

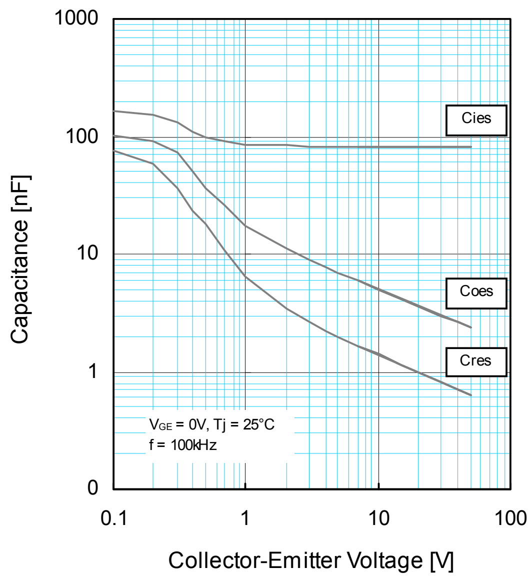


FREE-WHEEL DIODE FORWARD CHARACTERISTICS (TYPICAL)

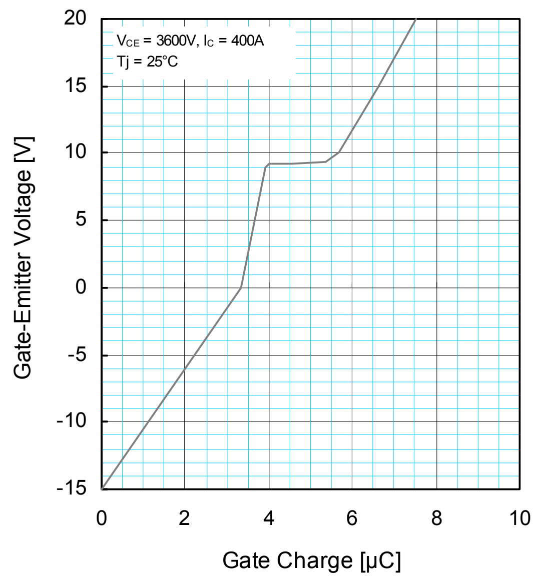


PERFORMANCE CURVES

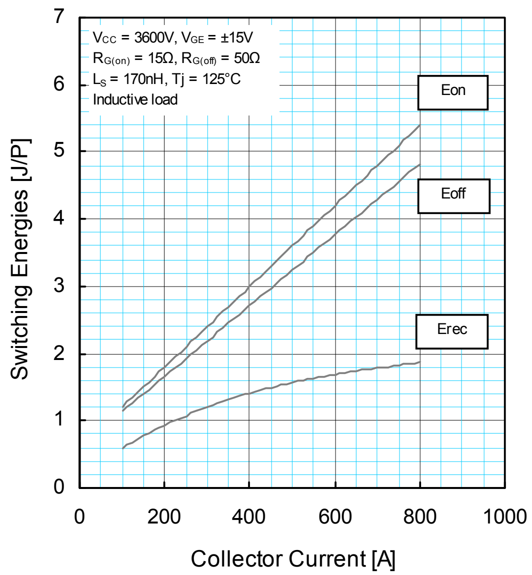
CAPACITANCE CHARACTERISTICS (TYPICAL)



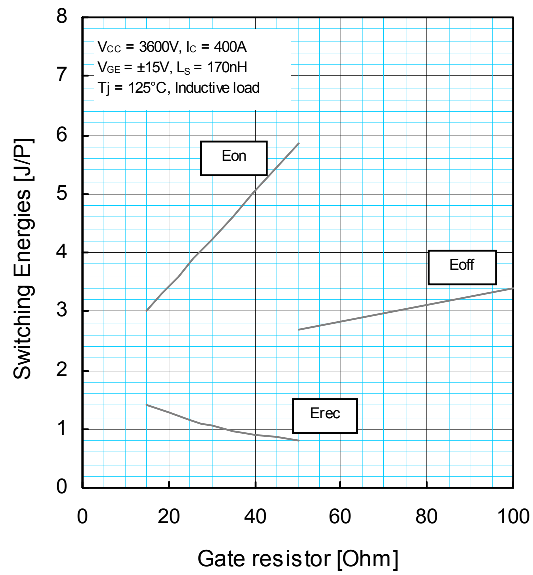
GATE CHARGE CHARACTERISTICS (TYPICAL)



HALF-BRIDGE SWITCHING ENERGY CHARACTERISTICS (TYPICAL)

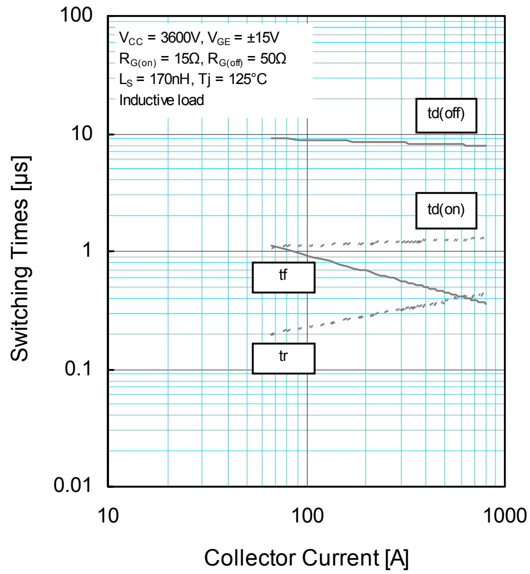


HALF-BRIDGE SWITCHING ENERGY CHARACTERISTICS (TYPICAL)

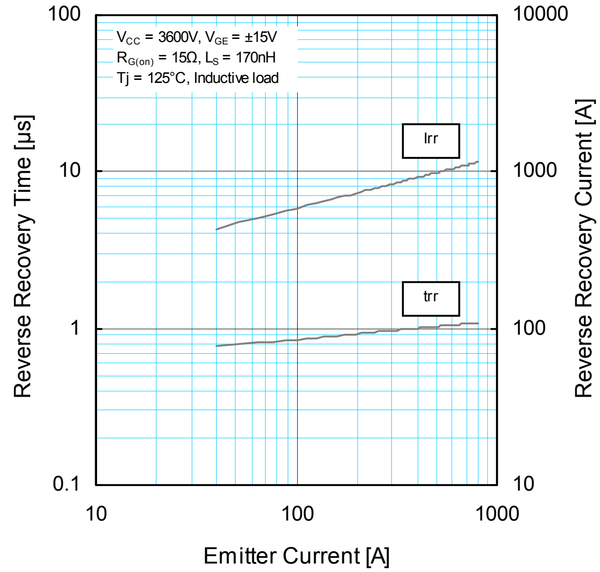


PERFORMANCE CURVES

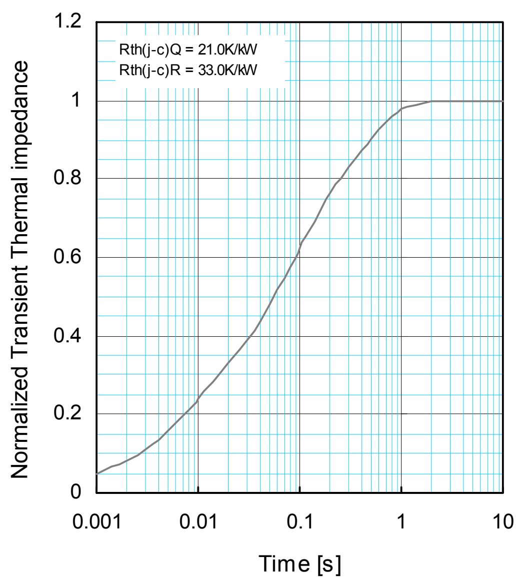
HALF-BRIDGE SWITCHING TIME CHARACTERISTICS (TYPICAL)



FREE-WHEEL DIODE REVERSE RECOVERY CHARACTERISTICS (TYPICAL)



TRANSIENT THERMAL IMPEDANCE CHARACTERISTICS

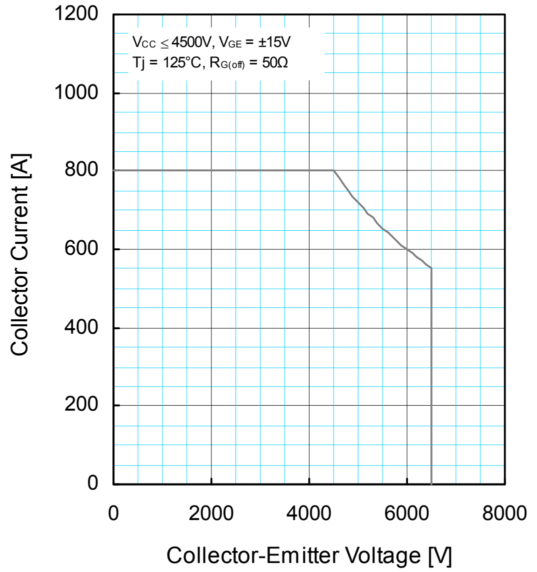


$$Z_{th(j-c)}(t) = \sum_{i=1}^{n} R_i \left\{ 1 - exp^{\left(-\frac{t}{\tau_i}\right)} \right\}$$

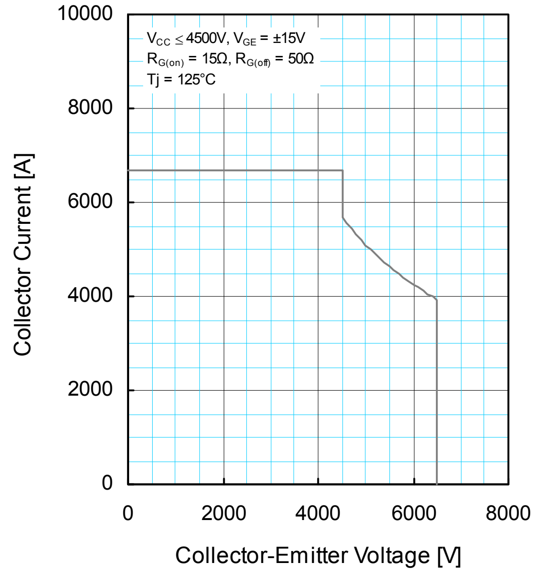
	1	2	3	4
R_i [K/kW] :	0.0096	0.1893	0.4044	0.3967
τ_i [sec] :	0.0001	0.0058	0.0602	0.3512

PERFORMANCE CURVES

REVERSE BIAS SAFE OPERATING AREA (RBSOA)



SHORT CIRCUIT SAFE OPERATING AREA (SCSOA)



FREE-WHEEL DIODE REVERSE RECOVERY SAFE OPERATING AREA (RRSOA)