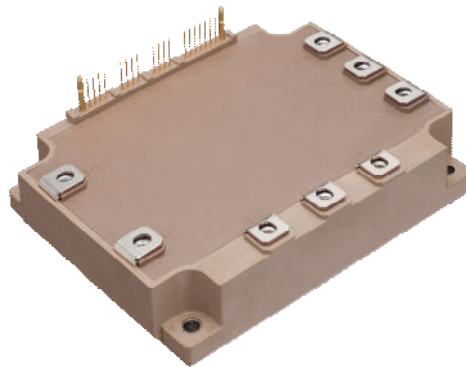


IGBT Modules

■ Features

- Temperature protection provided by directly detecting the junction temperature of the IGBTs
- Low power loss and soft switching
- High performance and high reliability IGBT with overheating protection
- Higher reliability because of a big decrease in number of parts in built-in control circuit



FM6M2043a
2023/03

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IGBT Modules

Absolute maximum ratings

 $T_C=25^{\circ}\text{C}$, $T_{vj}=25^{\circ}\text{C}$, $V_{CC}=15\text{V}$ unless otherwise specified

Item	Symbol	Conditions	Min.	Max.	Units
Collector-Emitter voltage	V_{CES}	*1	-	650	V
Short circuit voltage	V_{SC}	*2	200	400	V
Inverter	Collector current	I_C DC	-	450	A
		I_{CP} 1ms	-	900	A
		$-I_C$ Duty=100% *3	-	450	A
	Total power dissipation	P_{tot} IGBT 1 device *4	-	1530	W
Brake	Repetitive peak reverse voltage	V_{RRM} Diode part	-	-	V
	Collector current	I_C DC	-	-	A
		I_{CP} 1ms	-	-	A
	Forward current of diode	I_F	-	-	A
	Total power dissipation	P_{tot} IGBT 1 device *4	-	-	W
Supply voltage of pre-driver	V_{CC}	*5	-0.5	20	V
Input signal voltage	V_{in}	*6	-0.5	$V_{CC}+0.5$	V
Alarm signal voltage	V_{ALM}	*7	-0.5	V_{CC}	V
Alarm signal current	I_{ALM}	*8	-	20	mA
T_{vj} warning signal voltage	V_{WNG}	*9	-0.5	V_{CC}	V
T_{vj} warning signal current	I_{WNG}	*10	-	20	mA
Virtual junction temperature	T_{vj}		-	175	$^{\circ}\text{C}$
Operating virtual junction temperature	T_{vjop}		-	150	$^{\circ}\text{C}$
Operating case temperature	T_C		-20	125	$^{\circ}\text{C}$
Storage temperature	T_{stg}		-40	125	$^{\circ}\text{C}$
Solder temperature	T_{sol}	*11	-	260	$^{\circ}\text{C}$
Isolating voltage	V_{isol}	*12	-	2500	Vrms
Mounting torque of screws to heat sink	M_s	Mounting(M5)	2.5	3.5	Nm
Mounting torque of screws to terminals	M_t	Main terminals(M5)	2.5	3.5	Nm

Notes

*1: V_{CES} shall be applied to the input voltage between all Collector and Emitter]

[P1-(U,V,W), P2-(U,V,W), (U,V,W,B)-N1, (U,V,W,B)-N2]

*2: In the case of the load inductance to be over 1 μH .

*3: Duty=150 $^{\circ}\text{C}/R_{th(I-C)D}/(I_F \times V_F \text{ Max.}) \times 100$

*4: $P_{tot}=150^{\circ}\text{C}/R_{th(I-C)Q}$

*5: V_{CC} shall be applied to the input voltage between terminal No.3 and 1, 7 and 5, 11 and 9, 14 and 13.

*6: V_{in} shall be applied to the input voltage between terminal No.2 and 1, 6 and 5, 10 and 9, 16~18 and 13.

*7: V_{ALM} shall be applied to the voltage between terminal No.4 and 1, 8 and 5, 12 and 9, 19 and 13.

*8: I_{ALM} shall be applied to the input current to terminal No.4,8,12 and 19.

*9: V_{WNG} shall be applied to the voltage between terminal No.15 and 13.

*10: I_{WNG} shall be applied to the input current to terminal No.15.

*11: Immersion time 10 $\pm$ 1sec. 1 time.

*12: Terminal to base, 50/60Hz sine wave 1 min. All terminals should be connected together during the test.

Electrical characteristics

Main circuit

 $T_{vj}=25^{\circ}\text{C}$, $V_{CC}=15\text{V}$ unless otherwise specified

Item	Symbol	Conditions	Min.	Typ.	Max.	Units
Inverter	Collector current at off signal input	I_{CES} $V_{CE} = 650\text{V}$	-	-	1.0	mA
	Collector-Emitter saturation voltage *13	$V_{CE(sat)}$ $I_C = 450\text{A}$	Terminal	-	1.75	V
			Chip	-	1.15	V
	Forward voltage of FWD *13	V_F $I_F = 450\text{A}$	Terminal	-	2.25	V
			Chip	-	1.55	V
Brake	Collector current at off signal input	I_{CES} $V_{CE} = -V$	-	-	-	mA
	Reverse current	I_{RRM} $V_R = -V$	-	-	-	mA
	Collector-Emitter saturation voltage *13	$V_{CE(sat)}$ $I_C = -A$	Terminal	-	-	V
			Chip	-	-	V
	Forward voltage of FWD *13	V_F $I_F = -A$	Terminal	-	-	V
			Chip	-	-	V
Switching time *14	t_{on}	$I_C = 450\text{A}$ $T_{vj}=150^{\circ}\text{C}$	$V_{DC} = 300\text{V}$	0.5	-	μs
				0.5	-	μs
	t_{off}	$I_C = 450\text{A}$ $T_{vj}=150^{\circ}\text{C}$	$V_{DC} = 300\text{V}$	-	-	2.0
				-	-	1.7
	t_{tr}	$I_F = 450\text{A}$ $T_{vj}=150^{\circ}\text{C}$	$V_{DC} = 300\text{V}$	-	-	0.5

*13: The max value is a case where it measures from P2-(U,V,W,B), (U,V,W,B)-N2.

*14: Turn on time (t_{on}) = $t_{d(on)} + t_r$, Turn off time (t_{off}) = $t_{d(off)} + t_f$

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IGBT Modules

● Control circuit

$T_{vj}=25^{\circ}\text{C}$, $V_{CC}=15\text{V}$ unless otherwise specified

Item	Symbol	Conditions		Min.	Typ.	Max.	Units
Supply current of P-side pre-driver (per one unit)	I_{ccp}	Switching frequency (f_{sw}) = 0~15kHz T_C = -20~125°C		-	-	44	mA
Supply current of N-side pre-driver	I_{ccn}			-	-	135	mA
Input signal threshold voltage	$V_{in th(on)}$	V_{in-GND}	ON	1.2	1.4	1.6	V
	$V_{in th(off)}$		OFF	1.5	1.7	1.9	V

● Protection circuit

$T_{vj}=25^{\circ}\text{C}$, $V_{CC}=15\text{V}$ unless otherwise specified

Item	Symbol	Conditions	Min.	Typ.	Max.	Units
Over current protection level	I_{OC}	$T_{vj}=150^{\circ}\text{C}$	675	-	-	A
			-	-	-	A
Over current protection delay time	t_{dOC}	$T_{vj}=150^{\circ}\text{C}$	-	4.0	-	μs
Short circuit protection delay time	t_{dSC}	$T_{vj}=150^{\circ}\text{C}$	-	1.0	-	μs
IGBT chips over heating protection temperature level	T_{jOH}	Surface of IGBT chips	175	-	-	$^{\circ}\text{C}$
Over heating protection hysteresis	T_{jH}		-	20	-	$^{\circ}\text{C}$
IGBT chips warning temperature level	T_{jW}	Surface of IGBT chips (Y)	150	-	-	$^{\circ}\text{C}$
Warning hysteresis	T_{jWH}		-	10	-	$^{\circ}\text{C}$
Under voltage protection level	V_{UV}		11.0	-	12.5	V
Under voltage protection hysteresis	V_H		0.2	0.5	-	V
Alarm signal hold time	$t_{ALM(OC)}$	ALM-GND	1.0	2.0	2.4	ms
	$t_{ALM(UV)}$	$T_C=-20\sim 125^{\circ}\text{C}$	3.5	4.0	4.5	ms
	$t_{ALM(TjOH)}$	$V_{CC}\geq 10\text{V}$	7.0	8.0	9.0	ms
Warning signal hold time	t_{WNG}	WNG-GND $T_C=-20\sim 125^{\circ}\text{C}$	T_{jW} operating ~ cancellation			ms
Alarm signal voltage	V_{ALMH}	ALM-GND, without protection	14.5	-	15.0	V
Warning signal voltage	V_{WNGH}	WNG-GND, without warning	14.5	-	15.0	V
Resistance for current limit	R_{ALM}		960	-	1570	Ω
	R_{WNG}		960	-	1570	Ω

■ Thermal resistance characteristics ($T_C = 25^{\circ}\text{C}$)

Item			Symbol	Min.	Typ.	Max.	Units
Thermal resistance junction to case *15	Inverter	IGBT	$R_{th(i-c)Q}$	-	-	0.098	K/W
		FWD	$R_{th(i-c)D}$	-	-	0.142	K/W
	Brake	IGBT	$R_{th(i-c)Q}$	-	-	-	K/W
		FWD	$R_{th(i-c)D}$	-	-	-	K/W
Thermal resistance case to heat sink *16			$R_{th(c-s)}$	-	0.05	-	K/W

*15: For 1 device, the measurement point of the case is just under the chip.

*16: This is the value which is defined mounting on the additional heat sink with 1 W/(m·K) thermal grease.

■ Noise immunity ($V_{DC}=300\text{V}$, $V_{CC}=15\text{V}$)

Item	Conditions	Min.	Typ.	Max.	Units
Common mode rectangular noise	Pulse width 1 μs , polarity $\pm$, 10min. Judge: no over-current, no miss operating	± 2.0	-	-	kV

■ Recommended operating conditions

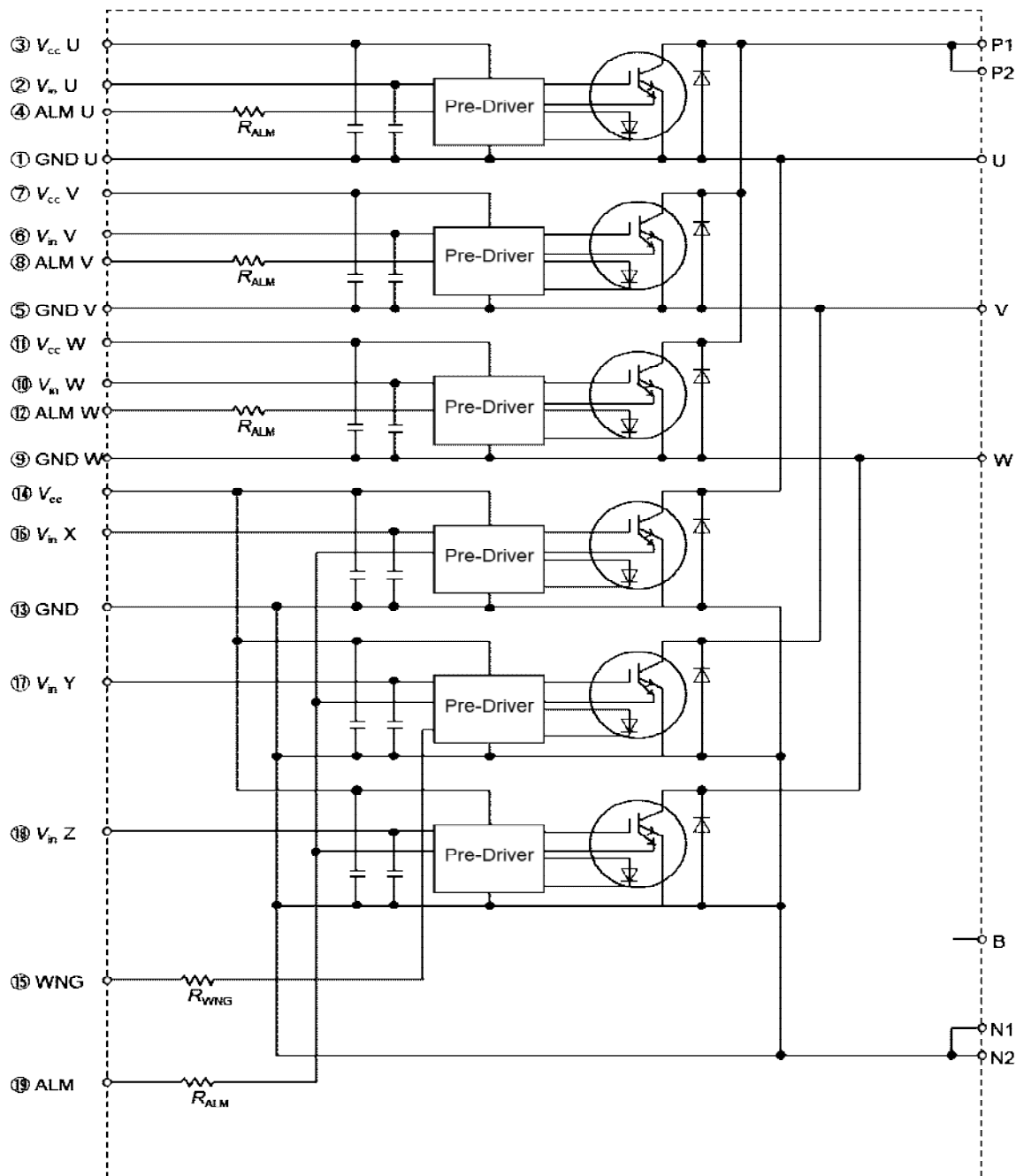
Item	Symbol	Min.	Typ.	Max.	Units
DC bus voltage	V_{DC}	-	-	400	V
Power supply voltage of pre-driver	V_{CC}	13.5	15.0	16.5	V
Switching frequency of IPM	f_{sw}	-	-	20.0	kHz
Arm short through blocking time for IPM's input signal *17	t_{dead}	1.5	-	-	μs
Screw torque (M5)	-	2.5	-	3.5	Nm

*17: $t_{dead} = t_{off} - t_{d(on)}$

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IGBT Modules

■ Block diagram



Pre-drivers include following functions

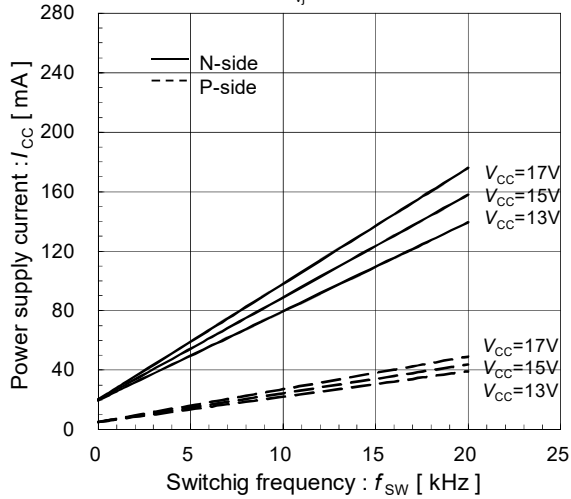
1. Amplifier for driver
2. Short circuit protection
3. Under voltage lockout circuit
4. Over current protection
5. IGBT chip over heating protection

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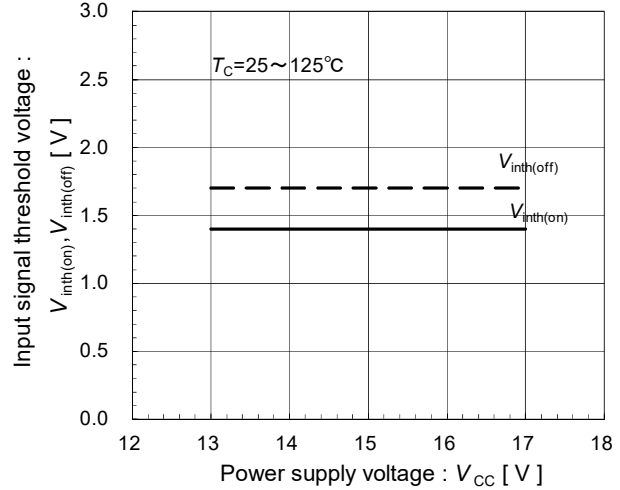
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■ Characteristics (representative)
● Control circuit

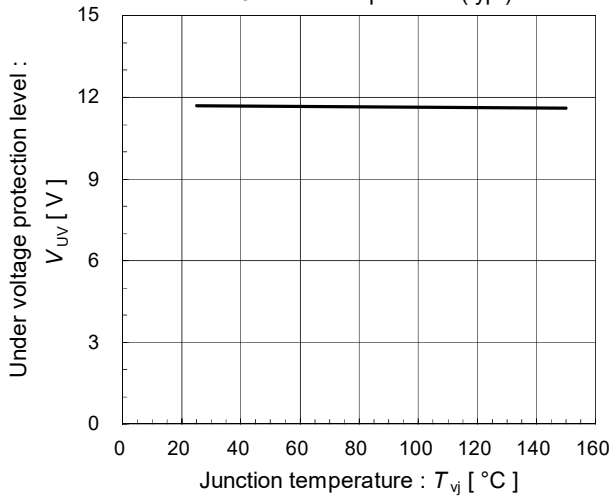
Power supply current vs. Switching frequency (typ.)
 $T_{vj} = 25^{\circ}\text{C}$



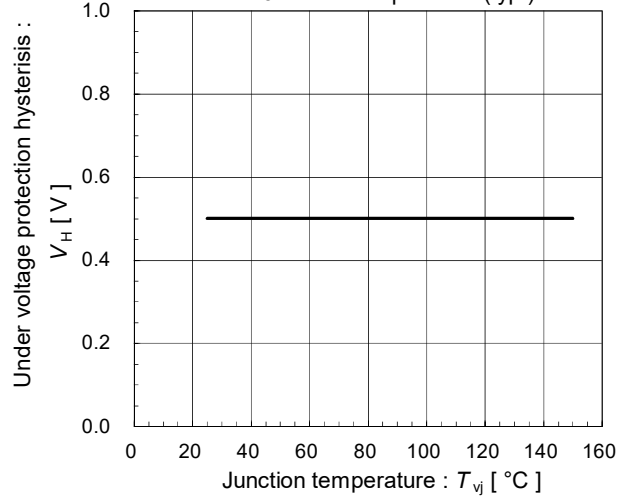
Input signal threshold voltage
vs. Power supply voltage (typ.)



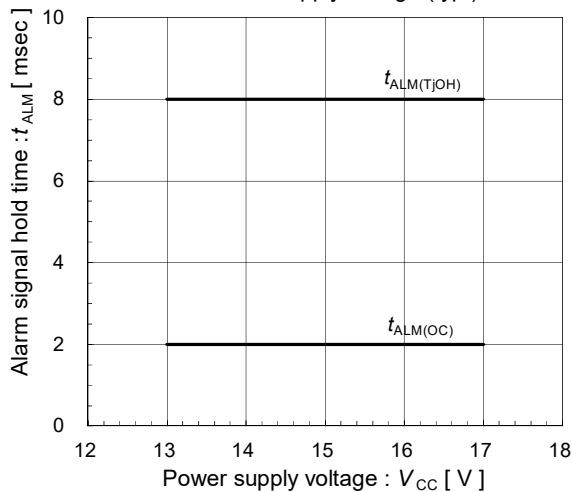
Under voltage protection level
vs. Junction temperature (typ.)



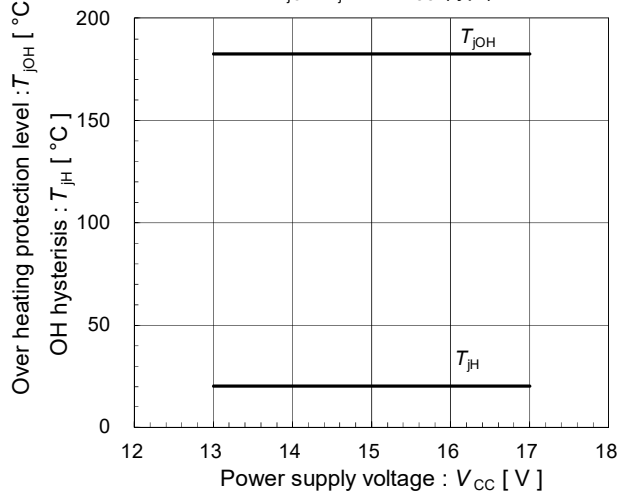
Under voltage protection hysteresis
vs. Junction temperature (typ.)



Alarm signal hold time
vs. Power supply voltage (typ.)



Over heating characteristics
 T_{JOH}, T_{JH} vs. V_{CC} (typ.)

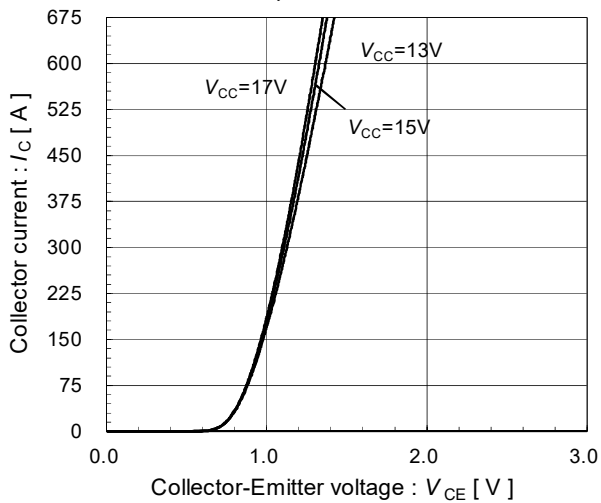


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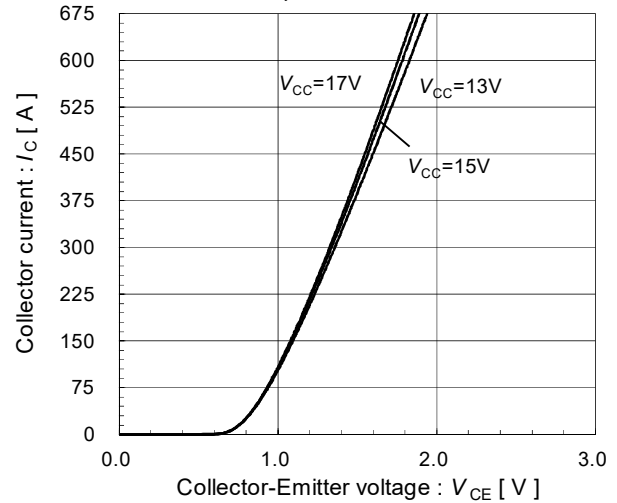
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● Inverter

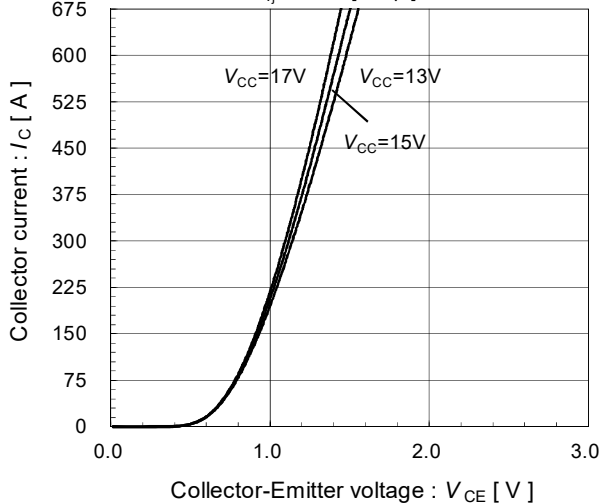
Collector current vs. Collector-Emitter voltage (typ.)
 $T_{vj}=25^{\circ}\text{C}$ [Chip]



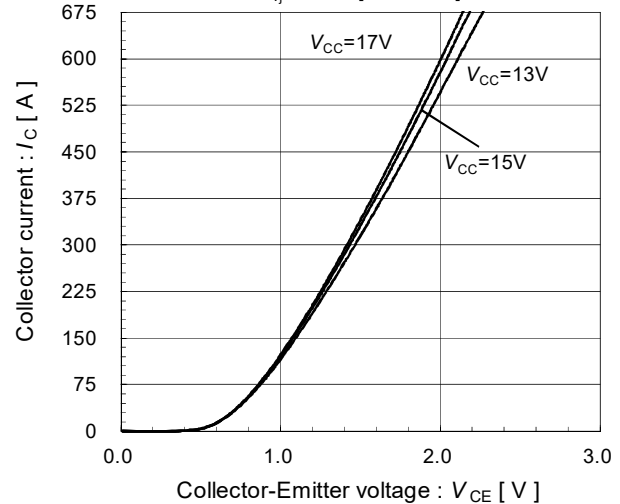
Collector current vs. Collector-Emitter voltage (typ.)
 $T_{vj}=25^{\circ}\text{C}$ [Terminal]



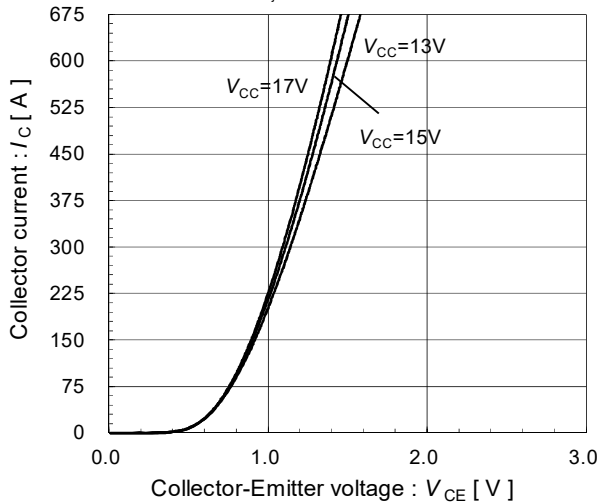
Collector current vs. Collector-Emitter voltage (typ.)
 $T_{vj}=125^{\circ}\text{C}$ [Chip]



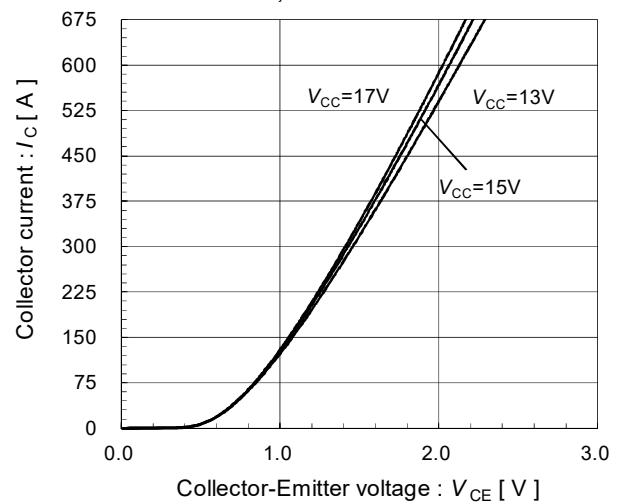
Collector current vs. Collector-Emitter voltage (typ.)
 $T_{vj}=125^{\circ}\text{C}$ [Terminal]



Collector current vs. Collector-Emitter voltage (typ.)
 $T_{vj}=150^{\circ}\text{C}$ [Chip]



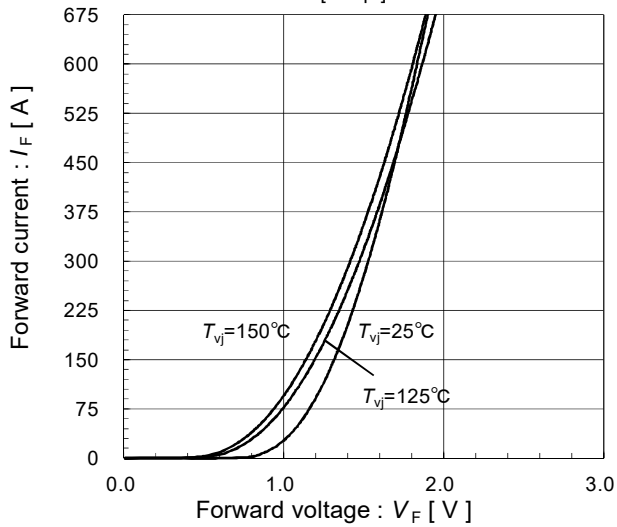
Collector current vs. Collector-Emitter voltage (typ.)
 $T_{vj}=150^{\circ}\text{C}$ [Terminal]



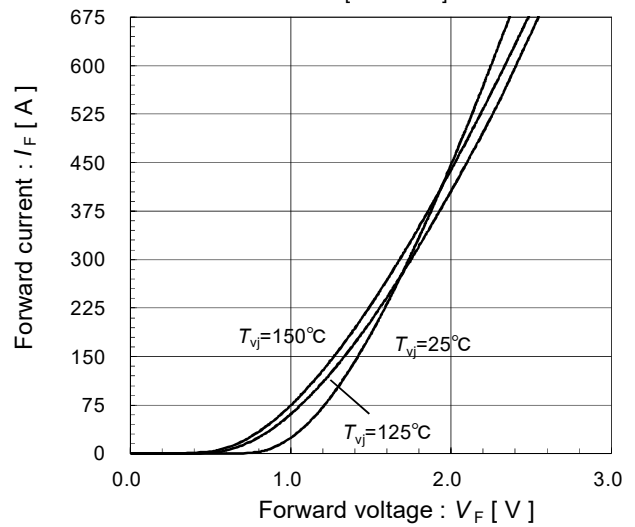
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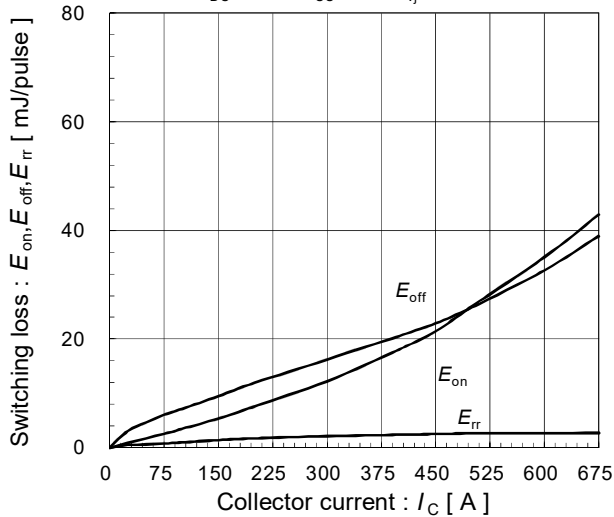
Forward current vs. Forward voltage (typ.)
[Chip]



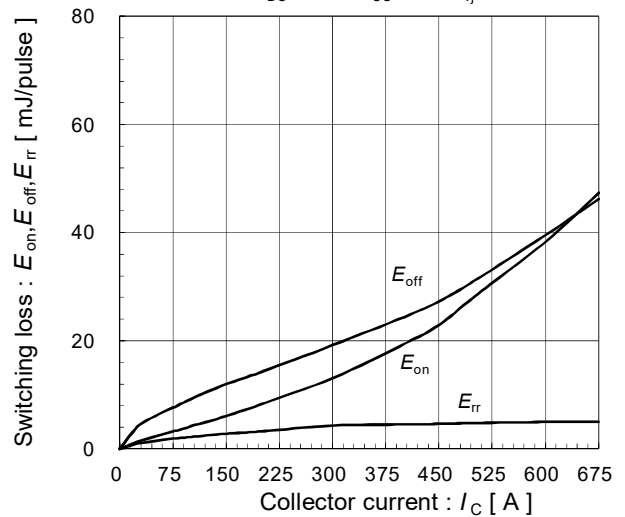
Forward current vs. Forward voltage (typ.)
[Terminal]



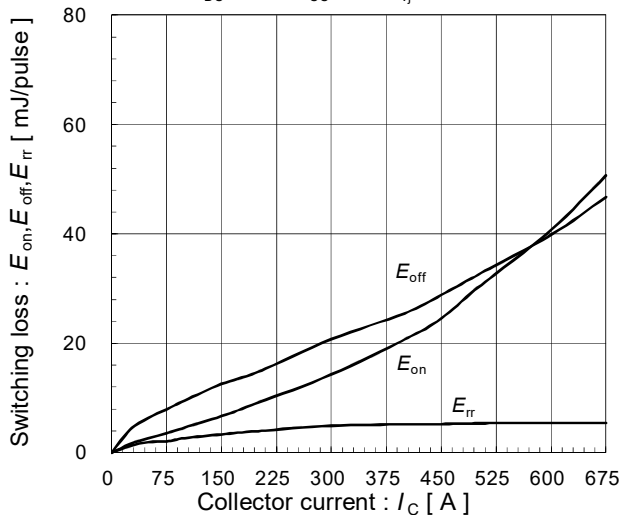
Switching loss vs. Collector current (typ.)
 $V_{DC}=300V, V_{CC}=15V, T_{vj}=25^{\circ}C$



Switching loss vs. Collector current (typ.)
 $V_{DC}=300V, V_{CC}=15V, T_{vj}=125^{\circ}C$



Switching loss vs. Collector current (typ.)
 $V_{DC}=300V, V_{CC}=15V, T_{vj}=150^{\circ}C$

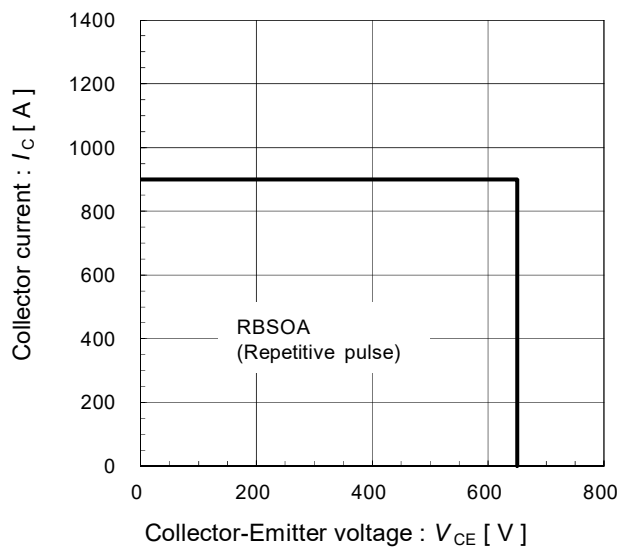


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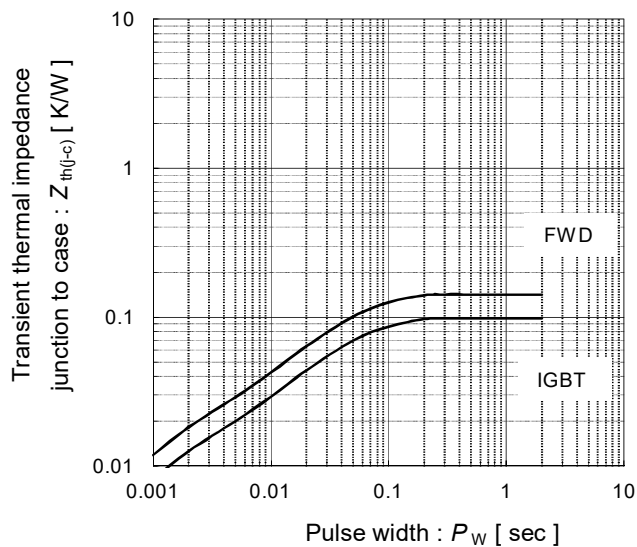
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Reversed biased safe operating area (max.)

$V_{CC}=15V, T_{vj}=150^{\circ}C$

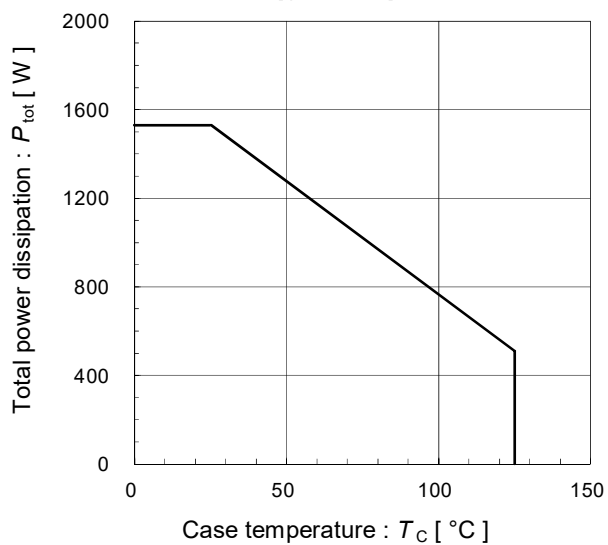


Transient thermal resistance (max.)



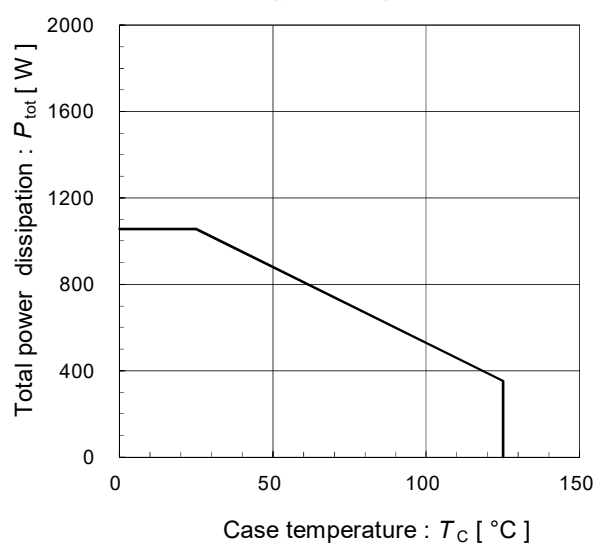
Power derating for IGBT (max.)

[per device]



Power derating for FWD (max.)

[per device]

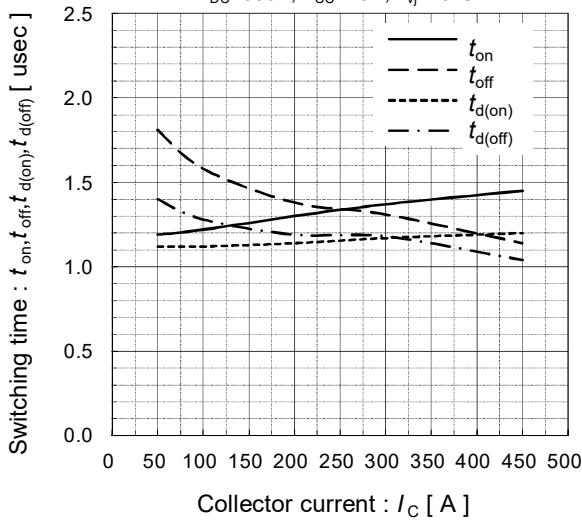


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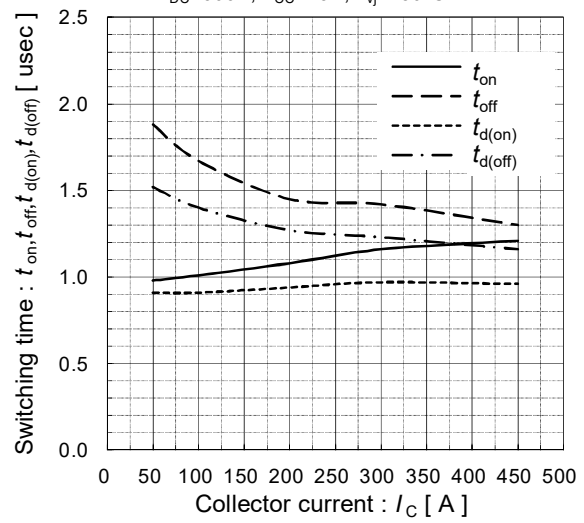
Switching time vs. Collector current (typ.)

$V_{DC}=300V, V_{CC}=15V, T_{vj}=25^{\circ}C$



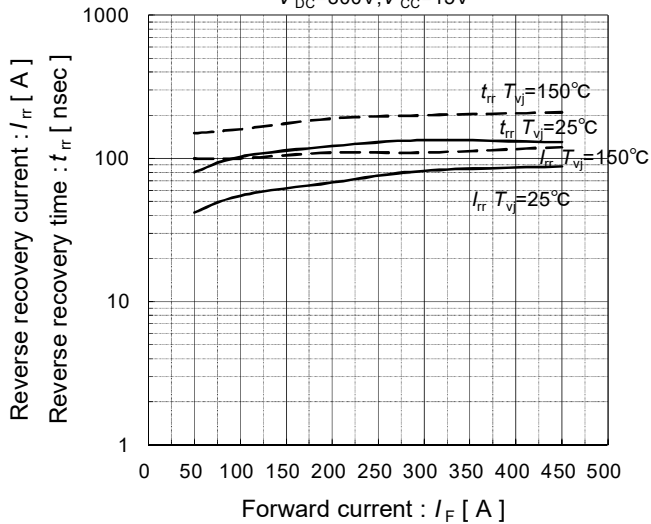
Switching time vs. Collector current (typ.)

$V_{DC}=300V, V_{CC}=15V, T_{vj}=150^{\circ}C$



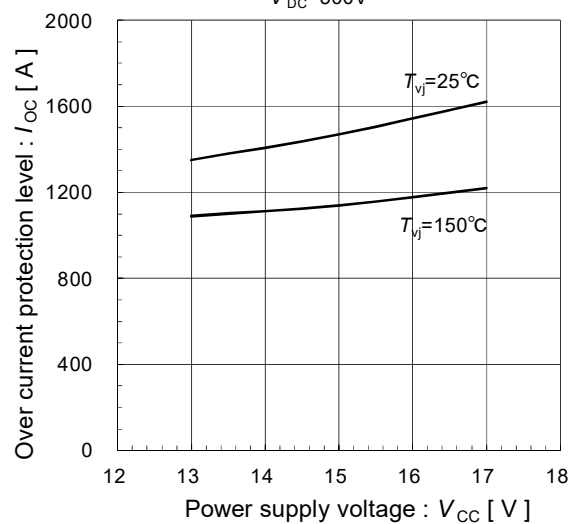
Reverse recovery characteristics (typ.)

$V_{DC}=300V, V_{CC}=15V$



Over current protection vs. Power supply voltage (typ.)

$V_{DC}=300V$



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