

<Intelligent Power Modules>

# PM35RG1AP120

FLAT-BASE TYPE  
INSULATED PACKAGE



## FEATURE

- a) Adopting Full-Gate CSTBT™ chip.
- b) The over-temperature protection which detects the chip surface temperature of CSTBT™ is adopted.
- c) Error output signal is available from each protection upper and lower arm of IPM.
- d) Outputting an error signal corresponding to the abnormal state (error mode identification)

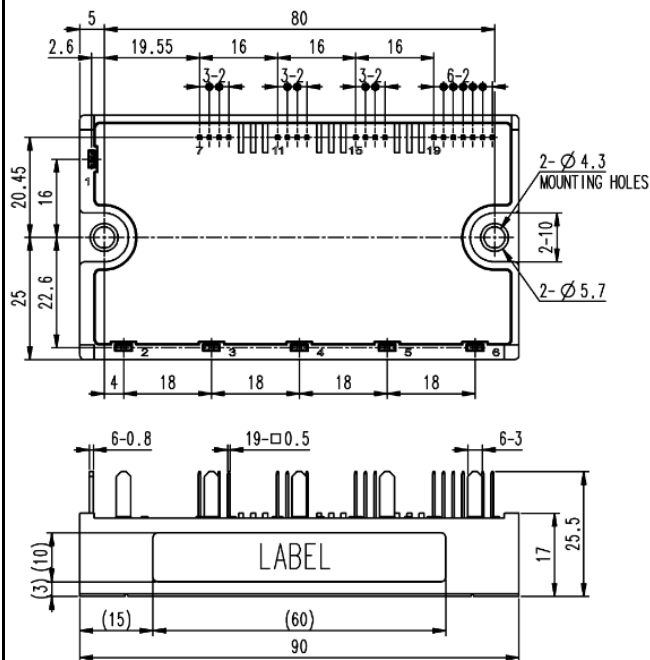
UL Recognized under UL1557, File No. E323585

This product is compliant with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) directive 2011/65/EU and (EU)2015/863.

## APPLICATION

General purpose inverter, servo drives and other motor controls

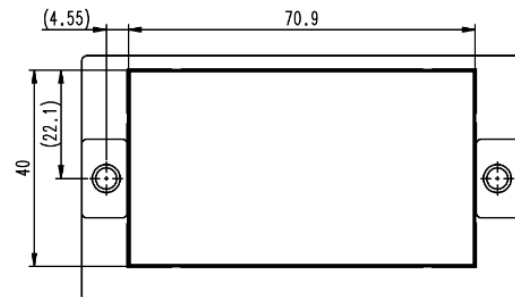
## PACKAGE OUTLINES



## Dimensions in mm

Tolerance otherwise specified

Division of Dimension		Tolerance
0.5	to 3	$\pm 0.2$
over 3	to 6	$\pm 0.3$
over 6	to 30	$\pm 0.5$
over 30	to 120	$\pm 0.8$
over 120	to 400	$\pm 1.2$



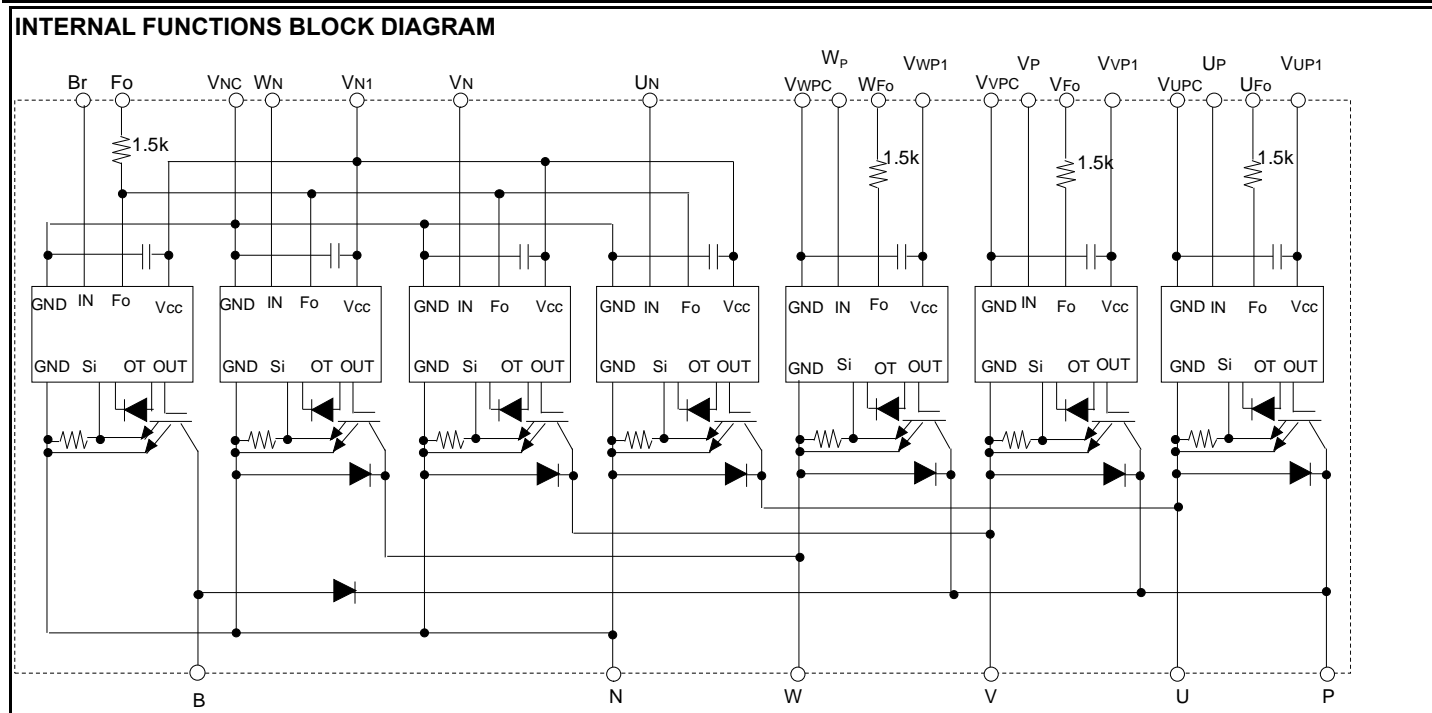
## TERMINAL CODE

1.B, 2.P, 3.N, 4.U, 5.V, 6.W, 7.V<sub>UPC</sub>, 8.U<sub>FO</sub>, 9.U<sub>P</sub>, 10.V<sub>UP1</sub>, 11.V<sub>VPC</sub>, 12.V<sub>FO</sub>, 13.V<sub>P</sub>, 14.V<sub>VP1</sub>, 15.V<sub>WPC</sub>, 16.W<sub>FO</sub>, 17.W<sub>P</sub>, 18.V<sub>WP1</sub>, 19.V<sub>NC</sub>, 20.V<sub>N1</sub>, 21.BR, 22.U<sub>N</sub>, 23.V<sub>N</sub>, 24.W<sub>N</sub>, 25.F<sub>O</sub>

# PM35RG1AP120

HIGH POWER SWITCHING USE

INSULATED TYPE



## MAXIMUM RATINGS (Tvj = 25°C, unless otherwise noted)

### INVERTER PART

Symbol	Parameter	Conditions	Ratings	Unit
$V_{CES}$	Collector-Emitter Voltage	$V_D=15\text{ V}, V_{CIN}=15\text{ V}$	1200	V
$I_C$	Collector Current	$T_C=25\text{ }^\circ\text{C}$	35	A
$I_{CRM}$		Pulse	70	
$P_{tot}$	Total Power Dissipation	$T_C=25\text{ }^\circ\text{C}$	290	W
$I_E$	Emitter Current	$T_C=25\text{ }^\circ\text{C}$	35	A
$I_{ERM}$	(Free-wheeling Diode Forward current)	Pulse	70	
$Tvj$	Junction Temperature	(Note5)	-20 ~ +150	°C

\*: Tc measurement point is just under the chip.

### BRAKE PART

Symbol	Parameter	Conditions	Ratings	Unit
$V_{CES}$	Collector-Emitter Voltage	$V_D=15\text{ V}, V_{CIN}=15\text{ V}$	1200	V
$I_C$	Collector Current	$T_C=25\text{ }^\circ\text{C}$	25	A
$I_{CRM}$		Pulse	50	
$P_{tot}$	Total Power Dissipation	$T_C=25\text{ }^\circ\text{C}$	260	W
$V_{R(DC)}$	Diode Rated Reverse DC Voltage	$T_C=25\text{ }^\circ\text{C}$	1200	V
$I_F$	Diode Forward Current	$T_C=25\text{ }^\circ\text{C}$	25	A
$Tvj$	Junction Temperature	(Note5)	-20 ~ +150	°C

\*: Tc measurement point is just under the chip.

### CONTROL PART

Symbol	Parameter	Conditions	Ratings	Unit
$V_D$	Supply Voltage	Applied between: $V_{UP1}-V_{UPC}, V_{VP1}-V_{VPC}, V_{WP1}-V_{WPC}, V_{N1}-V_{NC}$	20	V
$V_{CIN}$	Input Voltage	Applied between: $U_P-V_{UPC}, V_P-V_{VPC}, W_P-V_{WPC}, U_N, V_N, W_N, Br -V_{NC}$	20	V
$V_{FO}$	Fault Output Supply Voltage	Applied between: $U_{FO}-V_{UPC}, V_{FO}-V_{VPC}, W_{FO}-V_{WPC}, FO-V_{NC}$	20	V
$I_{FO}$	Fault Output Current	Sink current at $U_{FO}, V_{FO}, W_{FO}, FO$ terminals	20	mA

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## TOTAL SYSTEM

Symbol	Parameter	Conditions	Ratings	Unit
$V_{CC(Prot)}$	Supply Voltage Protected by SC	$V_D = 13.5 \text{ V} \sim 16.5 \text{ V}$ , Inverter Part, $T_{vj} = +125^\circ\text{C}$ start	800	V
$T_{stg}$	Storage Temperature	-	-40 ~ +125	$^\circ\text{C}$
$T_C$	Operating Case Temperature	(Note5)	-20 ~ +125	$^\circ\text{C}$
$V_{isol}$	Isolation Voltage	60Hz, Sinusoidal, Charged part to Base plate, AC 1min, RMS	2500	V

\*:  $T_C$  measurement point is just under the chip.

## THERMAL RESISTANCE

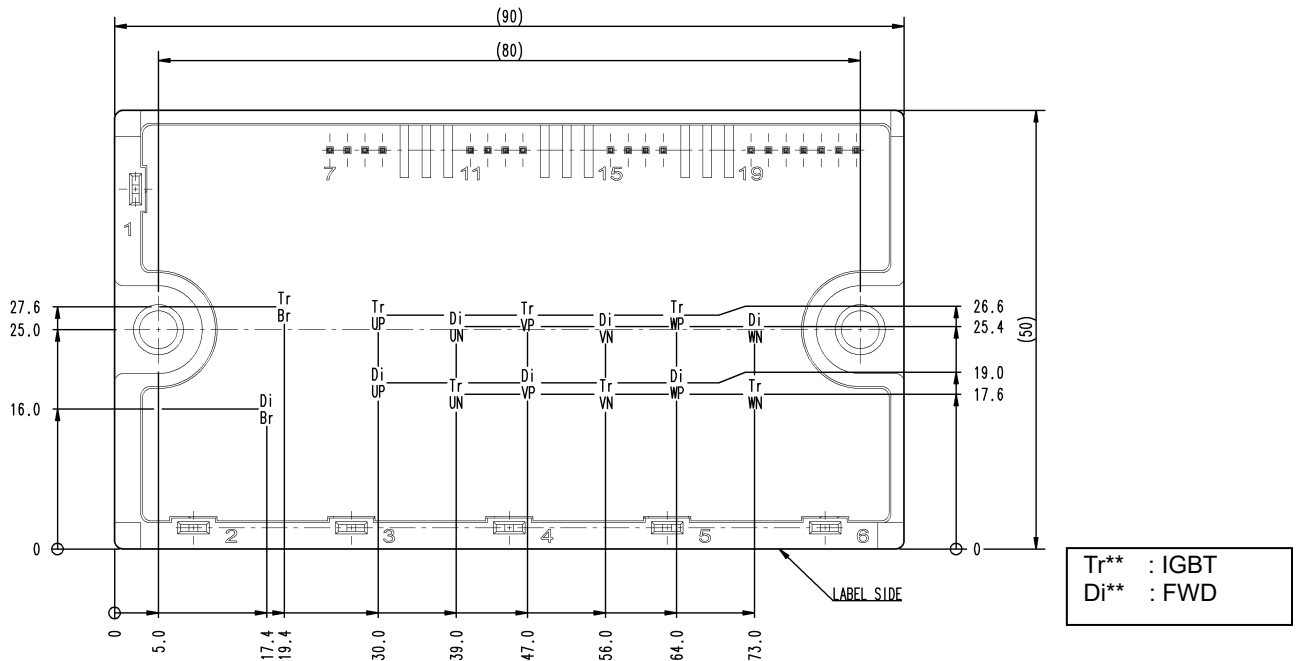
Symbol	Parameter	Conditions	Limits			Unit
			Min.	Typ.	Max.	
$R_{th(j-c)Q}$	Thermal Resistance	Inverter, Junction to case, IGBT, per 1 element (Note1)	-	-	0.43	K/W
$R_{th(j-c)D}$		Inverter, Junction to case, FWD, per 1 element (Note1)	-	-	0.67	
$R_{th(j-c)Q}$		Brake, Junction to case, IGBT, per 1 element (Note1)	-	-	0.48	
$R_{th(j-c)D}$		Brake, Junction to case, FWD, per 1 element (Note1)	-	-	0.78	
$R_{th(c-s)}$	Contact Thermal Resistance	Case to heat sink, per 1 module, Thermal grease applied (Note.1, 2, 5)	-	19.1	-	K/kW

Note1. If you use this value,  $R_{th(s-a)}$  should be measured just under the chips.

Note2. Typical value is by thermally conductive grease of  $\lambda = 0.9 \text{ W}/(\text{m} \cdot \text{K})$ ,  $D_{(c-s)} = 50 \text{ } \mu\text{m}$ .

### CHIP LOCATION (Top view)

Dimension in mm, tolerance:  $\pm 1 \text{ mm}$



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## ELECTRICAL CHARACTERISTICS (Tvj= 25°C, unless otherwise noted)

### INVERTER PART

Symbol	Parameter	Conditions			Limits			Unit
					Min.	Typ.	Max.	
V <sub>CEsat</sub>	Collector-Emitter Saturation Voltage	V <sub>D</sub> =15 V, I <sub>C</sub> =35 A	Tvj=25 °C	Terminal	-	-	1.7	V
				Chip	-	1.3	-	
		V <sub>CIN</sub> =0 V, Pulsed, (Fig.1)	Tvj=125 °C	Terminal	-	-	1.95	
				Chip	-	1.5	-	
V <sub>EC</sub>	Emitter-Collector Voltage	V <sub>D</sub> =15 V, I <sub>E</sub> =35 A,	Tvj=25 °C	Terminal	-	-	2.35	V
				Chip	-	1.75	-	
		V <sub>CIN</sub> = 15 V, pulsed, (Fig.2)	Tvj=125 °C	Terminal	-	-	2.6	
				Chip	-	1.95	-	
t <sub>on</sub>	Switching Time	V <sub>D</sub> =15 V, V <sub>CIN</sub> =0 V↔15 V, V <sub>CC</sub> =600 V, I <sub>C</sub> =35A, Tvj=125 °C, Inductive Load (Fig.3, 4)			0.3	0.7	1.2	μs
t <sub>rr</sub>					-	0.13	0.4	
t <sub>c(on)</sub>					-	0.2	0.4	
t <sub>off</sub>					-	1.0	2.8	
t <sub>c(off)</sub>					-	0.4	1.2	
I <sub>CES</sub>	Collector-Emitter Cut-off Current	V <sub>CE</sub> =V <sub>CES</sub> , V <sub>D</sub> =15 V, V <sub>CIN</sub> =15 V (Fig.5)		Tvj=25 °C	-	-	1	mA
				Tvj=125 °C	-	-	10	

### BRAKE PART

Symbol	Parameter	Conditions			Limits			Unit
					Min.	Typ.	Max.	
V <sub>CEsat</sub>	Collector-Emitter Saturation Voltage	V <sub>D</sub> =15 V, I <sub>C</sub> =25 A	Tvj=25 °C	Terminal	-	-	1.7	V
				Chip	-	1.3	-	
		V <sub>CIN</sub> =0 V, Pulsed, (Fig.1)	Tvj=125 °C	Terminal	-	-	1.95	
				Chip	-	1.5	-	
V <sub>FM</sub>	Diode Forward Voltage	I <sub>F</sub> =25A	Tvj=25 °C	Terminal	-	-	2.35	V
				Chip	-	1.75	-	
			Tvj=125 °C	Terminal	-	-	2.6	
				Chip	-	1.95	-	
I <sub>CES</sub>	Collector-Emitter Cut-off Current	V <sub>CE</sub> =V <sub>CES</sub> , V <sub>D</sub> =15 V, V <sub>CIN</sub> =15 V (Fig.5)		Tvj=25 °C	-	-	1	mA
				Tvj=125 °C	-	-	10	

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## ELECTRICAL CHARACTERISTICS (Tvj = 25°C, unless otherwise noted)

### CONTROL PART

Symbol	Parameter	Conditions	Limits			Unit	
			Min.	Typ.	Max.		
I <sub>D</sub>	Circuit Current	V <sub>D</sub> =15 V, V <sub>CIN</sub> =15 V	V <sub>P1</sub> -V <sub>PC</sub>	-	4	6	mA
			V <sub>N1</sub> -V <sub>NC</sub>	-	16	24	
		V <sub>D</sub> =15 V, V <sub>CIN</sub> =0 V ↔ 15 V, V <sub>CC</sub> =800 V I <sub>C</sub> =0A, Tvj=125 °C, f <sub>C</sub> ≤20kHz	V <sub>P1</sub> -V <sub>PC</sub>	-	13	15	
			V <sub>N1</sub> -V <sub>NC</sub>	-	48	56	
V <sub>th(ON)</sub>	Input ON Threshold Voltage	Applied between:	1.2	1.5	1.8	V	
V <sub>th(OFF)</sub>	Input OFF Threshold Voltage	U <sub>P</sub> -V <sub>UPC</sub> , V <sub>P</sub> -V <sub>VPC</sub> , W <sub>P</sub> -V <sub>WPC</sub> , U <sub>N</sub> , V <sub>N</sub> , W <sub>N</sub> , Br-V <sub>NC</sub>	1.7	2.0	2.3		
SC	Short Circuit Trip Level	-20≤Tvj≤125 °C, V <sub>D</sub> =15 V (Fig.3, 6)	Inverter	70	-	-	A
			Brake	50	-	-	
t <sub>d(SC)</sub>	Short Circuit Current Delay Time	V <sub>D</sub> =15 V, Tvj=125 °C (Fig.3, 6)	-	2.0	-	μs	
OT	Over Temperature Protection	Detect temperature of IGBT chip surface	Trip level	150	-	-	°C
			Hysteresis	-	20	-	
UV <sub>t</sub>	Supply Circuit	-	Trip level	11.0	12.0	12.7	V
UV <sub>r</sub>	Under-Voltage Protection		Reset level	-	12.5	-	
I <sub>FO(H)</sub>	Fault Output Current	V <sub>D</sub> =15 V, V <sub>FO</sub> =15 V (Note3)	-	-	0.01	mA	
I <sub>FO(L)</sub>			-	10	15		
t <sub>FO</sub>	Fault Output Pulse Width	V <sub>D</sub> =15 V (Note3)	OT	-	8.0	-	ms
			UV	-	4.0	-	
			SC	-	2.0	-	

Note3. Fault output is given only when the internal SC, OT & UV protections schemes of either upper or lower arm device operate to protect it.

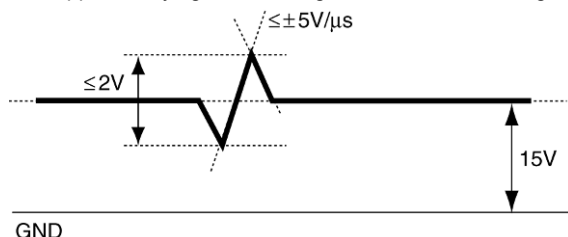
### MECHANICAL RATINGS AND CHARACTERISTICS

Symbol	Parameter	Conditions	Limits			Unit
			Min.	Typ.	Max.	
M <sub>s</sub>	Mounting Torque	Mounting part screw : M4	1.5	1.7	2.0	N•m
m	mass	-	-	175	-	g

### RECOMMENDED CONDITIONS FOR USE

Symbol	Parameter	Conditions	Recommended value	Unit
V <sub>CC</sub>	Supply Voltage	Applied across P-N terminals	≤ 800	V
V <sub>D</sub>	Control Supply Voltage	Applied between : V <sub>UP1</sub> -V <sub>UPC</sub> , V <sub>VP1</sub> -V <sub>VPC</sub> , V <sub>WP1</sub> -V <sub>WPC</sub> , V <sub>N1</sub> -V <sub>NC</sub> (Note4)	15.0±1.5	V
V <sub>CIN(ON)</sub>	Input ON Voltage	Applied between : U <sub>P</sub> -V <sub>UPC</sub> , V <sub>P</sub> -V <sub>VPC</sub> , W <sub>P</sub> -V <sub>WPC</sub> , U <sub>N</sub> , V <sub>N</sub> , W <sub>N</sub> , Br-V <sub>NC</sub>	≤ 0.8	V
V <sub>CIN(OFF)</sub>	Input OFF Voltage		≥ 9.0	
f <sub>PWM</sub>	PWM Input Frequency	Using Application Circuit of Fig. 8	≤ 20	kHz
t <sub>dead</sub>	Arm Shoot-through Blocking Time	For IPM's each input signals (Fig.7)	≥ 2.5	μs

Note4. With ripple satisfying the following conditions: dv/dt swing ≤ ±5 V/μs, Variation ≤ 2 V peak to peak



Note5. Long term performance related to thermal conductive material such as thermal grease (including but not limited to aspects such as the increase of thermal resistance due to pumping out, etc.) should be verified under your specific application conditions. Each temperature condition (Tvj, Tc) must be maintained below the maximum rated temperature throughout consideration of the temperature rise even for long term usage.

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HIGH POWER SWITCHING USE  
INSULATED TYPE

## PRECAUTIONS FOR TESTING

1. Before applying any control supply voltage ( $V_D$ ), the input terminals should be pulled up by resistors, etc. to their corresponding supply voltage and each input signal should be kept off state.

After this, the specified ON and OFF level setting for each input signal should be done.

2. When performing "SC" tests, the turn-off surge voltage spike at the corresponding protection operation should not be allowed to rise above  $V_{CES}$  rating of the device.

(These test should not be done by using a curve tracer or its equivalent.)

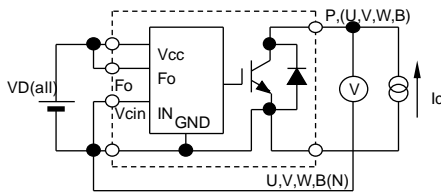


Fig.1  $V_{CESat}$  Test

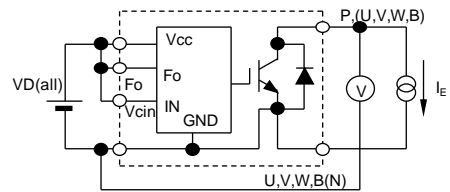


Fig.2  $V_{EC}$  Test

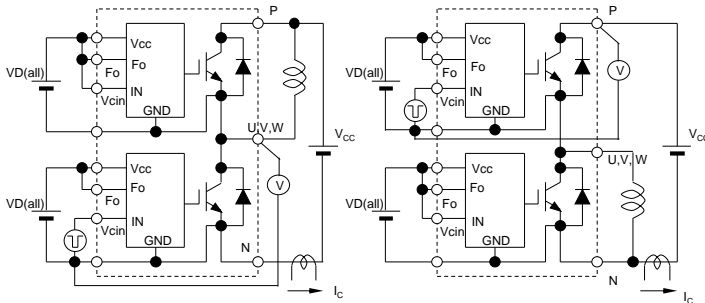


Fig.3 Switching time and SC test circuit

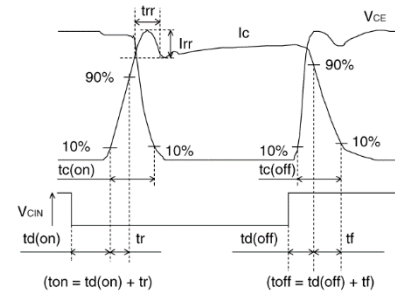


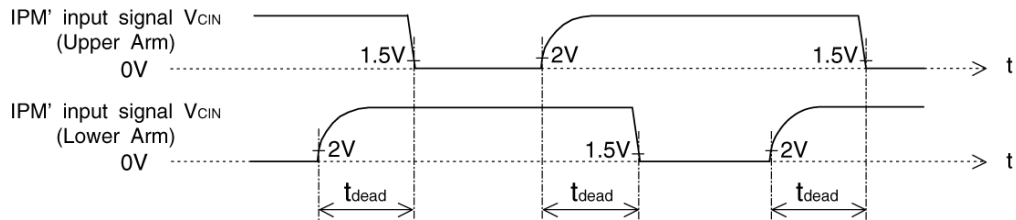
Fig.4 Switching time test waveform



Fig.5  $I_{CES}$  Test



Fig.6 SC test waveform



1.5V: Input on threshold voltage  $V_{th(on)}$  typical value, 2V: Input off threshold voltage  $V_{th(off)}$  typical value

Fig. 7 Dead time measurement point example

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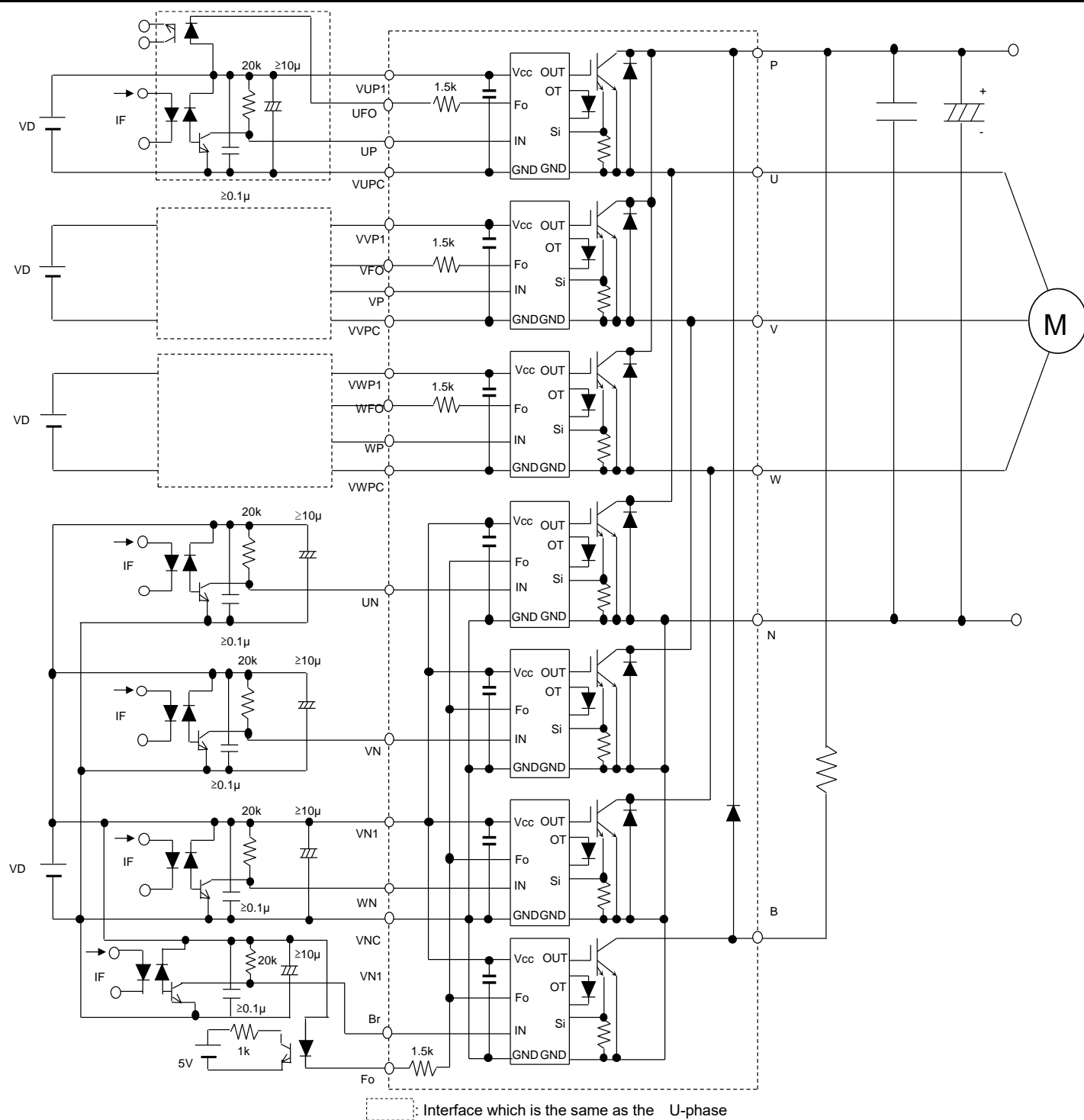


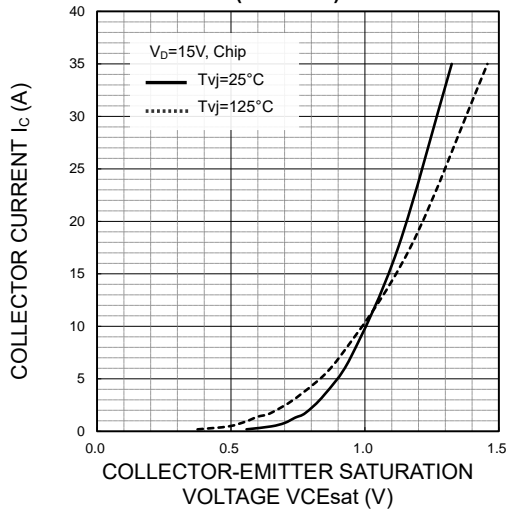
Fig. 8 Application Example Circuit

### NOTES FOR STABLE AND SAFE OPERATION ;

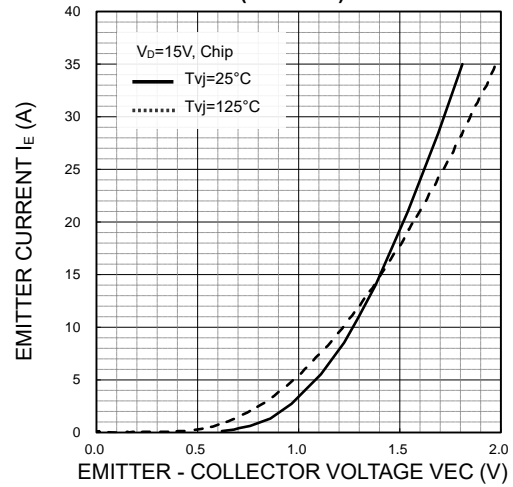
- Design the PCB pattern to minimize wiring length between opto-coupler and IPM's input terminal, and also to minimize the stray capacity between the input and output wirings of opto-coupler.
- Connect low impedance capacitor between the Vcc and GND terminal of each fast switching opto-coupler.
- Fast switching opto-couplers:  $t_{PLH}$ ,  $t_{PHL} \leq 0.8\mu s$ , Use High CMR type.
- Slow switching opto-coupler: CTR > 100% (\*can be applied to Brake part input signal, in this case, resistor should be selected properly).
- Use 4 isolated control power supplies (VD). Also, care should be taken to minimize the instantaneous voltage charge of the power supply.
- Make inductance of DC bus line as small as possible, and minimize surge voltage using snubber capacitor between P and N terminal.

PERFORMANCE CURVES  
Inverter part

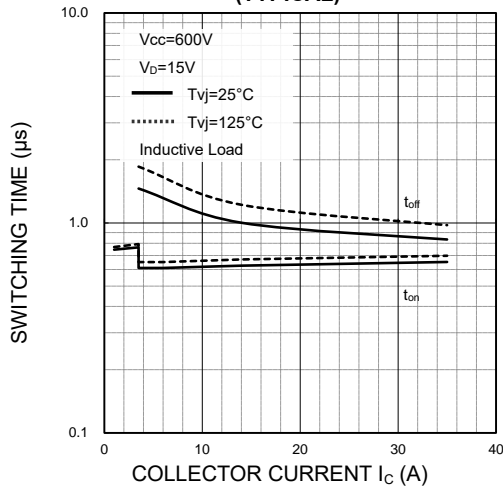
COLLECTOR-EMITTER SATURATION VOLTAGE (VS.  $I_c$ ) CHARACTERISTICS (TYPICAL)



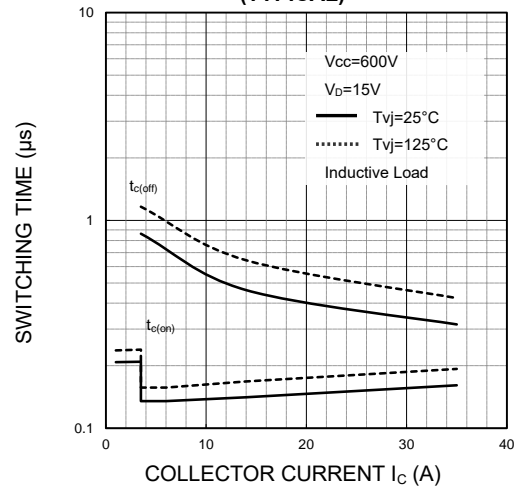
FREE WHEELING DIODE FORWARD CHARACTERISTICS (TYPICAL)



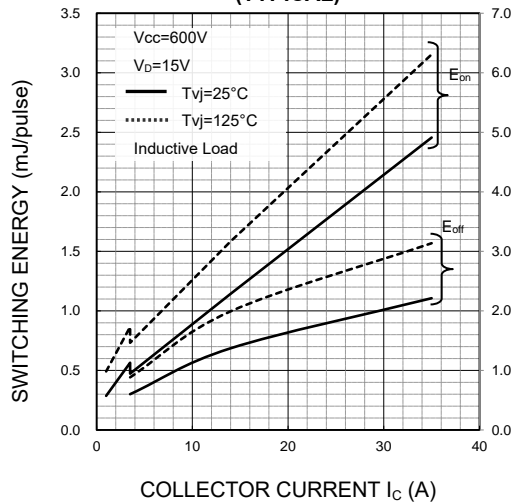
SWITCHING TIME ( $t_{on}$ ,  $t_{off}$ ) CHARACTERISTICS (TYPICAL)



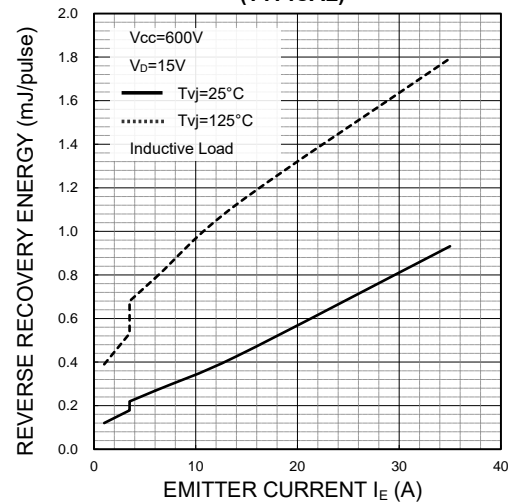
SWITCHING TIME ( $t_{c(on)}$ ,  $t_{c(off)}$ ) CHARACTERISTICS (TYPICAL)



SWITCHING ENERGY CHARACTERISTICS (TYPICAL)



FREE WHEELING DIODE REVERSE RECOVERY ENERGY CHARACTERISTICS (TYPICAL)

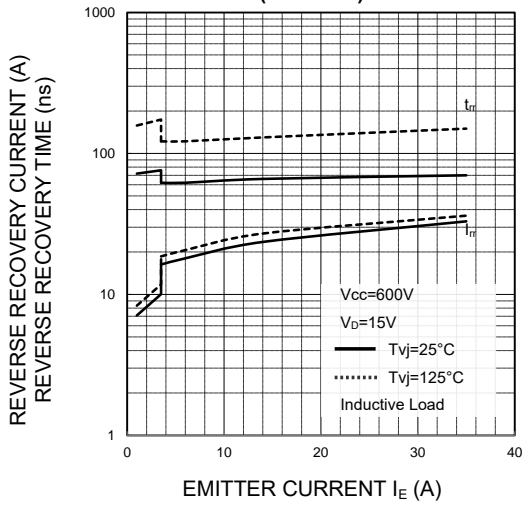




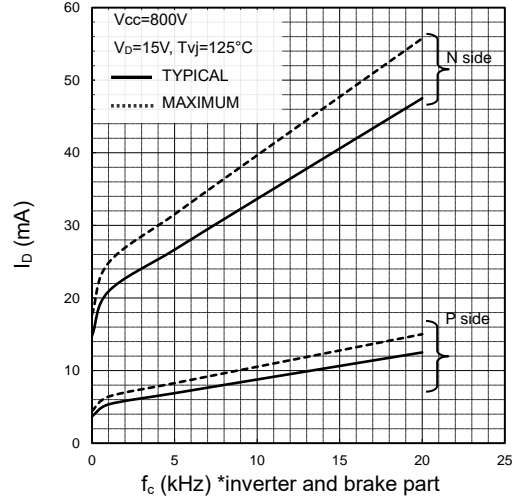
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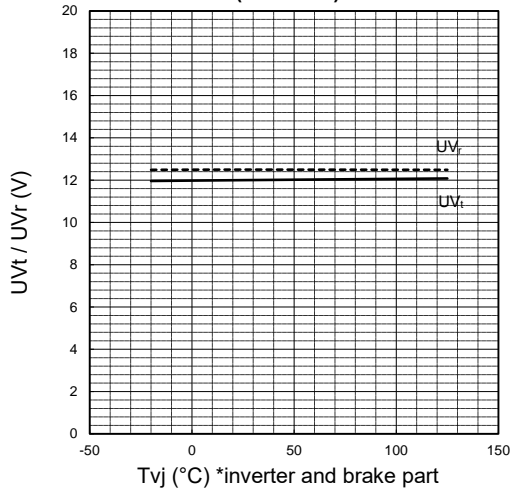
**FREE WHEELING DIODE REVERSE RECOVERY CHARACTERISTICS (TYPICAL)**



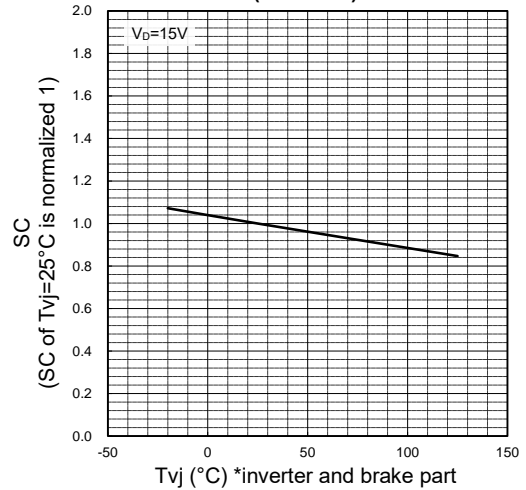
**$I_D$  VS.  $f_c$  CHARACTERISTICS (TYPICAL, MAXIMUM)**



**UV TRIP LEVEL VS.  $T_{vj}$  CHARACTERISTICS (TYPICAL)**

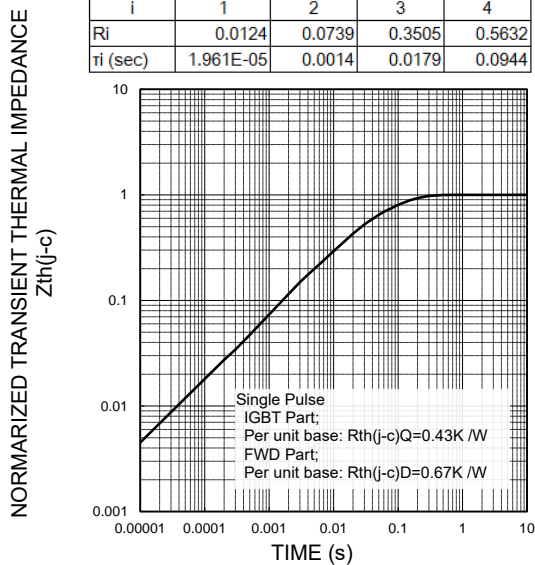


**SC TRIP LEVEL VS.  $T_{vj}$  CHARACTERISTICS (TYPICAL)**



**TRANSIENT THERMAL IMPEDANCE CHARACTERISTICS (TYPICAL)**

i	1	2	3	4
$R_{ti}$	0.0124	0.0739	0.3505	0.5632
$t_i$ (sec)	1.961E-05	0.0014	0.0179	0.0944

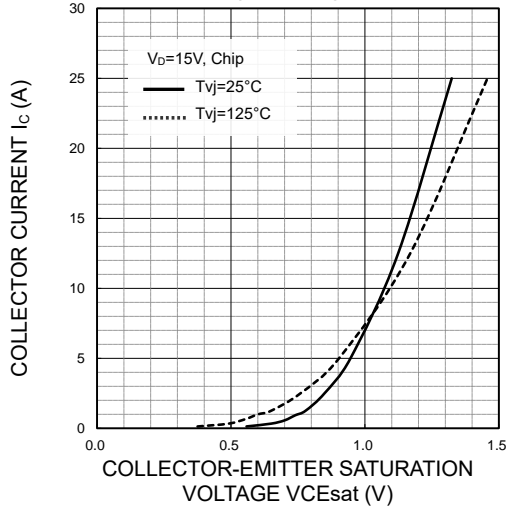


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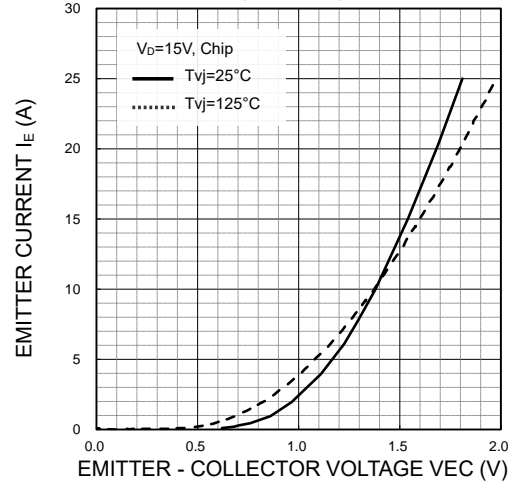
HIGH POWER SWITCHING USE  
INSULATED TYPE

## PERFORMANCE CURVES Brake part

**COLLECTOR-EMITTER SATURATION VOLTAGE (VS.  $I_c$ ) CHARACTERISTICS (TYPICAL)**

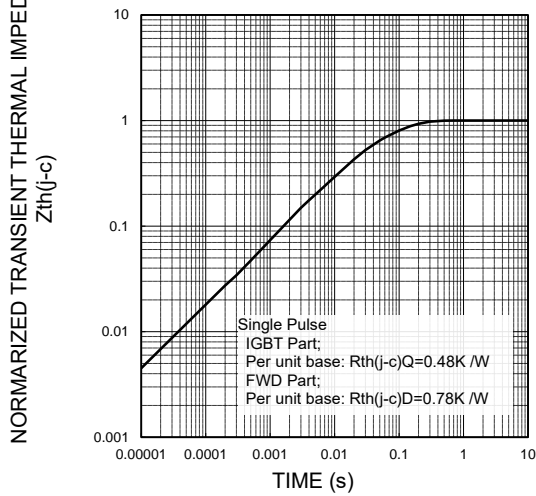


**FREE WHEELING DIODE FORWARD CHARACTERISTICS (TYPICAL)**



**TRANSIENT THERMAL IMPEDANCE CHARACTERISTICS (TYPICAL)**

i	1	2	3	4
Ri	0.0124	0.0739	0.3505	0.5632
ti (sec)	1.961E-05	0.0014	0.0179	0.0944



**Note:**

The characteristics curves are presented for reference only and not guaranteed by production test, unless otherwise noted.

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HIGH POWER SWITCHING USE  
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### **Important Notice**

The information contained in this datasheet shall in no event be regarded as a guarantee of conditions or characteristics. This product has to be used within its specified maximum ratings, and is subject to customer's compliance with any applicable legal requirement, norms and standards.

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### **Keep safety first in your circuit designs!**

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