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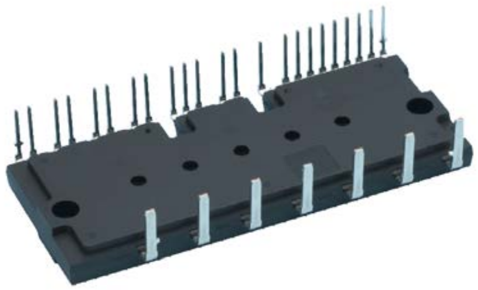
MITSUBISHI ELECTRIC

< Dual-In-Line Package Intelligent Power Module >

PSS05SA2FT

TRANSFER MOLDING TYPE
INSULATED TYPE

OUTLINE



MAIN FEATURES AND RATINGS

- 3 phase DC/AC inverter
- 1200V / 5A
- Built-in LPT-CSTBT (6th generation IGBT)
- Built-in bootstrap diodes with current limiting resistor
- Insulated transfer molding package
- N-side IGBT open emitter

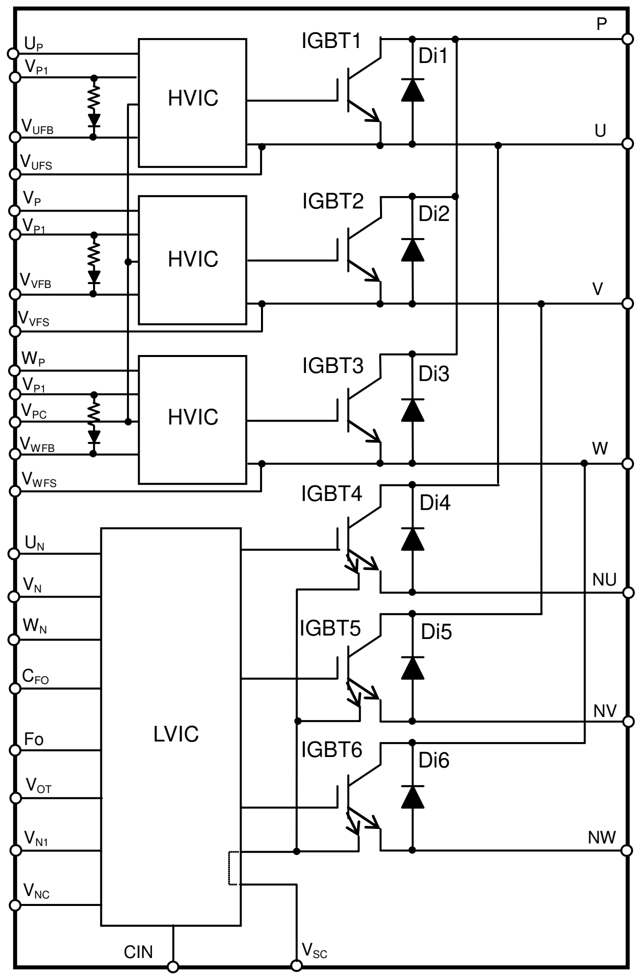
APPLICATION

- AC 400V class motor control

INTEGRATED DRIVE, PROTECTION AND SYSTEM CONTROL FUNCTIONS

- For P-side : Drive circuit, High voltage high-speed level shifting, Control supply under-voltage (UV) protection
- For N-side : Drive circuit, Control supply under-voltage protection (UV), Short circuit protection (SC)
- Fault signaling : Corresponding to SC fault (N-side IGBT), UV fault (N-side supply)
- Temperature output : Outputting LVIC temperature by analog signal
- Input interface : 5V line, Schmitt trigger receiver circuit (High Active)
- UL Recognized : UL1557 File E80276

INTERNAL CIRCUIT



Publication Date : March 2015

MITSUBISHI ELECTRIC CORPORATION

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

INVERTER PART

Symbol	Parameter	Condition	Ratings	Unit
V_{CC}	Supply voltage	Applied between P-NU,NV,NW	900	V
$V_{CC(surge)}$	Supply voltage (surge)	Applied between P-NU,NV,NW	1000	V
V_{CES}	Collector-emitter voltage		1200	V
$\pm I_C$	Each IGBT collector current	T_C= 25°C (Note 1)	5	A
$\pm I_{CP}$	Each IGBT collector current (peak)	T_C= 25°C, up to 1ms	10	A
P_C	Collector dissipation	T_C= 25°C, per 1 chip	44.6	W
T_j	Junction temperature		-30~+150	°C

Note 1: Pulse width and period are limited due to junction temperature.

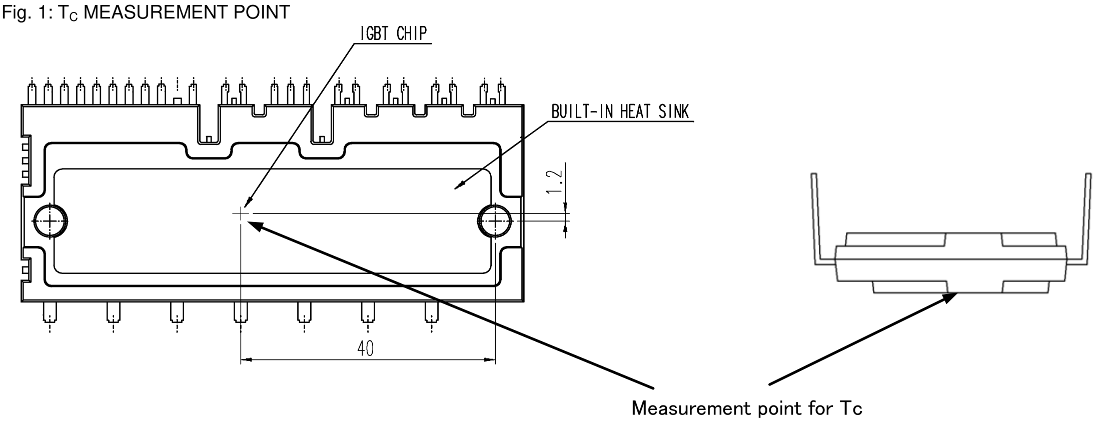
CONTROL (PROTECTION) PART

Symbol	Parameter	Condition	Ratings	Unit
V_D	Control supply voltage	Applied between V_{P1}-V_{PC}, V_{N1}-V_{NC}	20	V
V_{DB}	Control supply voltage	Applied between V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}	20	V
V_{IN}	Input voltage	Applied between U_P, V_P, W_P-V_{PC}, U_N, V_N, W_N-V_{NC}	-0.5~V_D+0.5	V
V_{FO}	Fault output supply voltage	Applied between F_O-V_{NC}	-0.5~V_D+0.5	V
I_{FO}	Fault output current	Sink current at F_O terminal	5	mA
V_{SC}	Current sensing input voltage	Applied between CIN-V_{NC}	-0.5~V_D+0.5	V

TOTAL SYSTEM

Symbol	Parameter	Condition	Ratings	Unit
$V_{CC(PROT)}$	Self protection supply voltage limit (Short circuit protection capability)	V_D = 13.5~16.5V, Inverter Part T_j = 125°C, non-repetitive, up to 2μs	800	V
T_C	Module case operation temperature	Tc measurement point is defined in Fig.1.	-30~+100	°C
T_{stg}	Storage temperature		-40~+125	°C
V_{iso}	Isolation voltage	60Hz, Sinusoidal, AC 1min, between connected all pins and heat sink plate	2500	V_{rms}

Fig. 1: T_C MEASUREMENT POINT



THERMAL RESISTANCE

Symbol	Parameter	Condition	Limits Min.	Limits Typ.	Limits Max.	Unit
$R_{th(j-c)Q}$	Junction to case thermal resistance (Note 2)	Inverter IGBT part (per 1/6 module)	-	-	2.24	K/W
$R_{th(j-c)F}$		Inverter FWDi part (per 1/6 module)	-	-	2.74	K/W

Note 2: Grease with good thermal conductivity and long-term endurance should be applied evenly with about +100μm~+200μm on the contacting surface of DIPIPM and heat sink. The contacting thermal resistance between DIPIPM case and heat sink Rth(c-f) is determined by the thickness and the thermal conductivity of the applied grease. For reference, Rth(c-f) is about 0.2K/W (per 1/6 module, grease thickness: 20μm, thermal conductivity: 1.0W/m•k).

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

INVERTER PART

Symbol	Parameter	Condition		Limits Min.	Limits Typ.	Limits Max.	Unit
$V_{CE(sat)}$	Collector-emitter saturation voltage	V_D=V_{DB} = 15V, V_{IN}= 5V, I_C= 5A	T_j= 25°C	-	1.40	2.10	V
			T_j= 125°C	-	1.50	2.20	
V_{EC}	FWDi forward voltage	V_{IN}= 0V, -I_C= 5A		-	2.20	2.80	V
t_{on}	Switching times	V_{CC}= 600V, V_D= V_{DB}= 15V I_C= 5A, T_j= 125°C, V_{IN}= 0↔5V Inductive Load (upper-lower arm)		1.30	2.00	2.70	μs
$t_{C(on)}$				-	0.50	0.80	μs
t_{off}				-	2.60	3.60	μs
$t_{C(off)}$				-	0.50	0.90	μs
t_{rr}				-	0.50	-	μs
I_{CES}	Collector-emitter cut-off current	V_{CE}=V_{CES}	T_j= 25°C	-	-	1	mA
			T_j= 125°C	-	-	10	

CONTROL (PROTECTION) PART

Symbol	Parameter	Condition		Limits Min.	Limits Typ.	Limits Max.	Unit
I_D	Circuit current	Total of V_{P1}-V_{PC}, V_{N1}-V_{NC}	V_D=15V, V_{IN}=0V	-	-	5.60	mA
			V_D=15V, V_{IN}=5V	-	-	5.60	
I_{DB}		Each part of V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}	V_{DB}=15V, V_{IN}=0V	-	-	1.10	
			V_{DB}=15V, V_{IN}=5V	-	-	1.10	
I_{SC}	Short circuit trip level	-30°C≤Tj≤125°C, Rs= 261Ω (±1%), Not connecting outer shunt resistors to NU,NV,NW terminals (Note 3)		8.5	-	-	A
UV_{DBt}	P-side Control supply under-voltage protection(UV)	T_j ≤125°C	Trip level	10.0	-	12.0	V
UV_{DBr}			Reset level	10.5	-	12.5	V
UV_{Dt}	N-side Control supply under-voltage protection(UV)	T_j ≤125°C	Trip level	10.3	-	12.5	V
UV_{Dr}			Reset level	10.8	-	13.0	V
V_{FOH}	Fault output voltage	V_{SC} = 0V, F_O terminal pulled up to 5V by 10kΩ		4.9	-	-	V
V_{FOL}		V_{SC} = 1V, I_{FO} = 1mA		-	-	0.95	V
t_{FO}	Fault output pulse width	C_{FO}=22nF (Note 4)		1.6	2.4	-	ms
I_{IN}	Input current	V_{IN} = 5V		0.70	1.00	1.50	mA
$V_{th(on)}$	ON threshold voltage	Applied between U_P, V_P, W_P, U_N, V_N, W_N-V_{NC}		-	-	3.5	V
$V_{th(off)}$	OFF threshold voltage			0.8	-	-	
V_{OT}	Temperature output	LVIC temperature = 75°C (Note 5)		2.26	2.38	2.51	V
V_F	Bootstrap Di forward voltage	I_F=10mA including voltage drop by limiting resistor (Note 6)		0.5	0.9	1.3	V
R	Built-in limiting resistance	Included in bootstrap Di		16	20	24	Ω

Note 3: Short circuit protection detects sense current divided from main current at N-side IGBT and works for N-side IGBT only. In the case that outer shunt resistor is inserted into main current path, protection current level I_{SC} changes. For details, please refer the application note for this DIPIPM.
4: Fault signal is output when short circuit or N-side control supply under-voltage protection works. The fault output pulse-width t_{FO} depends on the capacitance of C_{FO}. (C_{FO} (typ.) = t_{FO} x 9.1 x 10^{-6}) [F])
5: DIPIPM doesn't shut down IGBTs and output fault signal automatically when temperature rises excessively. When temperature exceeds the protective level that user defined, controller (MCU) should stop immediately. Temperature of LVIC vs. V_{OT} output characteristics is described in Fig.3
6: The characteristics of bootstrap Di is described in Fig.2.

Fig. 2 Characteristics of bootstrap Di V_F-I_F curve (@Ta=25°C) including voltage drop by limiting resistor (Right chart is enlarged chart.)

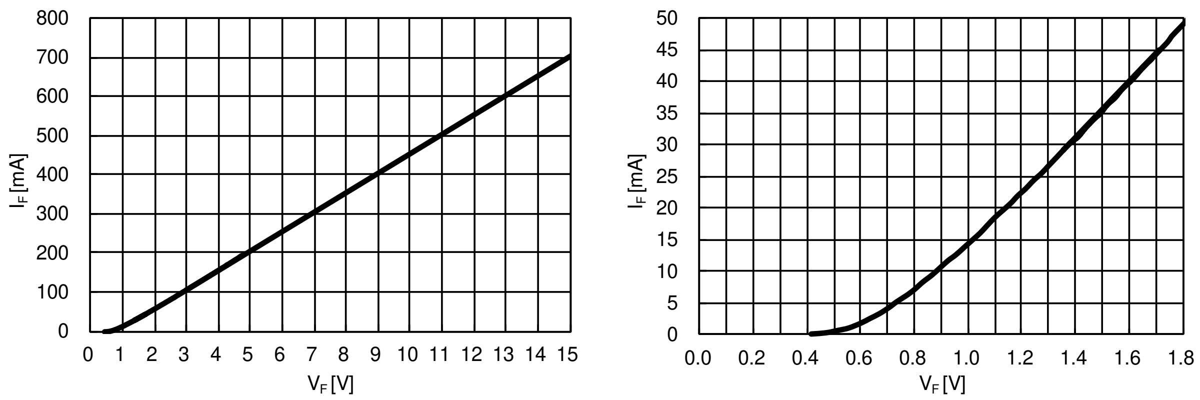
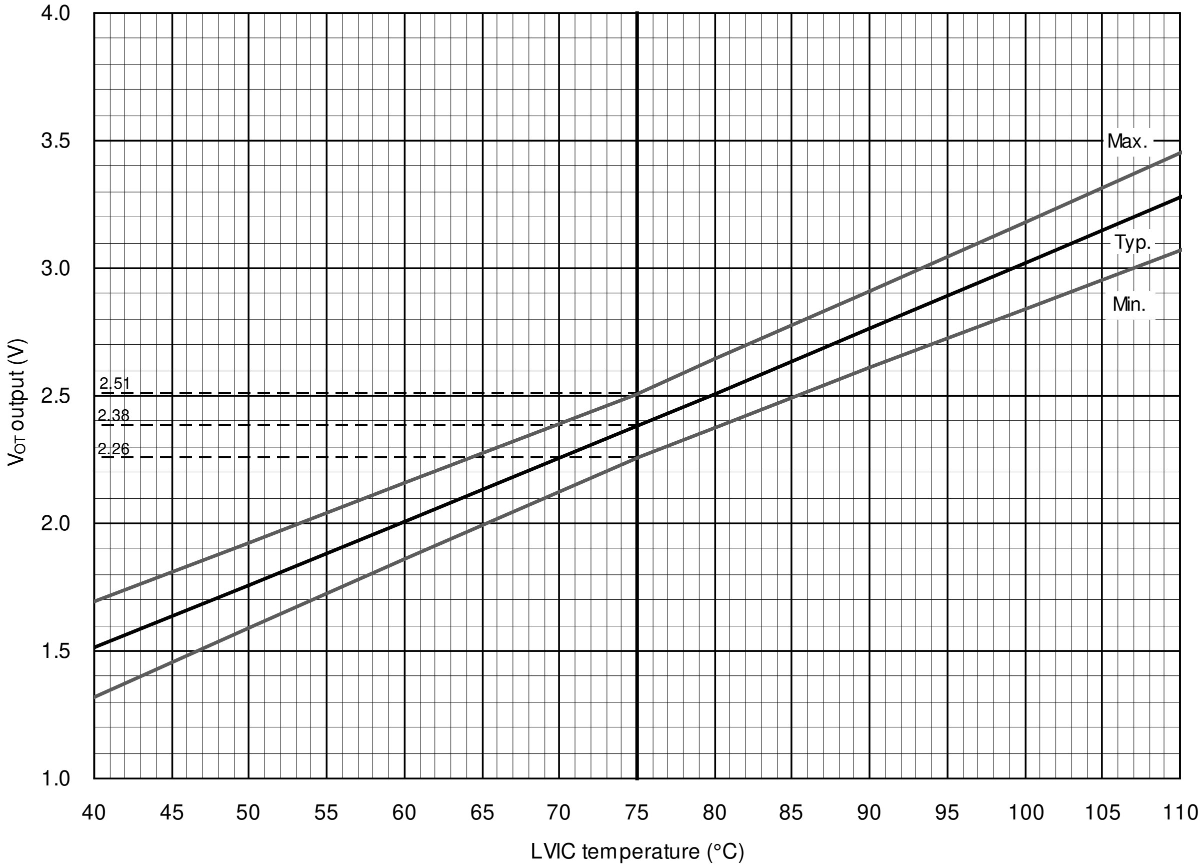
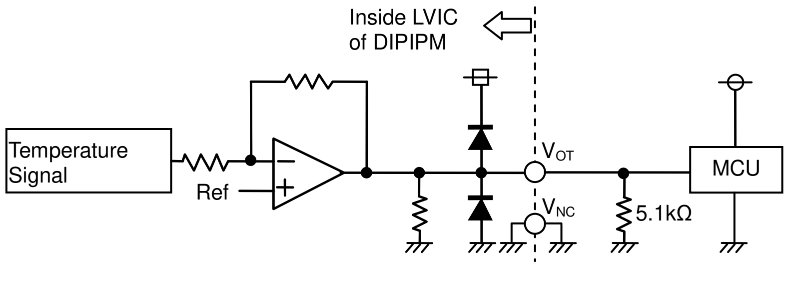


Fig. 3 Temperature of LVIC vs. V_{OT} Output Characteristics





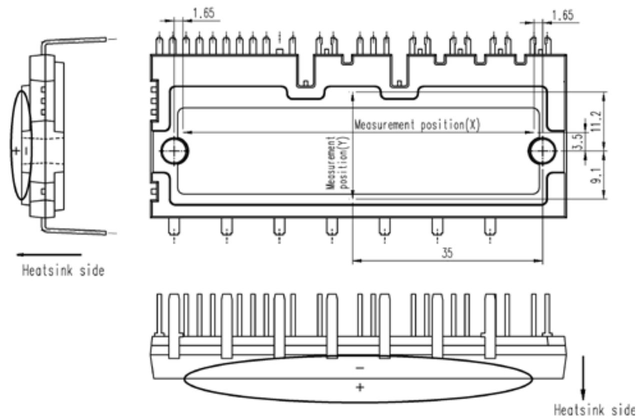
(1) It is recommended to insert 5.1kΩ pull down resistor for getting linear output characteristics at low temperature below room temperature. When the pull down resistor is inserted between V_{OT} and V_{NC}(control GND), the extra circuit current, which is calculated approximately by V_{OT} output voltage divided by pull down resistance, flows as LVIC circuit current continuously. In the case of using V_{OT} for detecting high temperature over room temperature only, it is unnecessary to insert the pull down resistor.
(2) In the case of not using V_{OT}, leave V_{OT} output NC (No Connection).

Refer the application note for this product about the usage of V_{OT}.

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M4 (Note 7)	Recommended 1.18N·m	0.98	1.18	1.47	N·m
Terminal pulling strength	Load 19.6N	EIAJ-ED-4701	10	-	-	s
Terminal bending strength	Load 9.8N, 90deg. bend	EIAJ-ED-4701	2	-	-	times
Weight			-	46	-	g
Heat-sink flatness		(Note 8)	-50	-	100	μm

Note 7: Plain washers (ISO 7089~7094) are recommended.
Note 8: Measurement point of heat-sink flatness

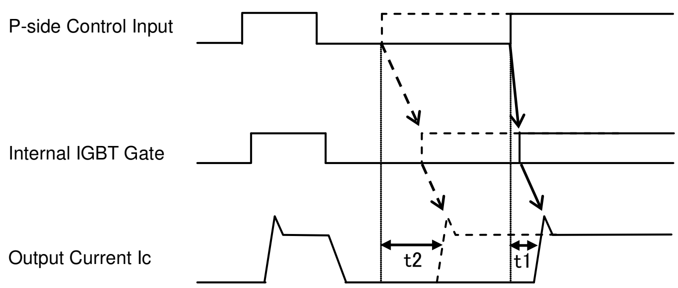


RECOMMENDED OPERATION CONDITIONS

Symbol	Parameter	Condition		Limits			Unit
				Min.	Typ.	Max.	
V_{CC}	Supply voltage	Applied between P-NU, NV, NW		350	600	800	V
V_D	Control supply voltage	Applied between V_{P1}-V_{PC}, V_{N1}-V_{NC}		13.5	15.0	16.5	V
V_{DB}	Control supply voltage	Applied between V_{UFB}-V_{UFS}, V_{VFB}-V_{VFS}, V_{WFB}-V_{WFS}		13.0	15.0	18.5	V
ΔV_D, ΔV_{DB}	Control supply variation			-1	-	+1	V/μs
t_{dead}	Arm shoot-through blocking time	For each input signal		3.0	-	-	μs
f_{PWM}	PWM input frequency	$T_C \leq 100°C$, $T_j \leq 125°C$		-	-	20	kHz
I_O	Allowable r.m.s. current	V_{CC} = 600V, V_D = 15V, P.F = 0.8, Sinusoidal PWM $T_C \leq 100°C$, $T_j \leq 125°C$ (Note 9)	f_{PWM}= 5kHz	-	-	2.7	Arms
			f_{PWM}= 15kHz	-	-	1.9	
PWIN(on)	Minimum input pulse width	(Note 10)		1.5	-	-	μs
PWIN(off)		350≤ V_{CC} ≤ 800V, 13.5≤ V_D ≤ 16.5V, 13.0≤ V_{DB} ≤ 18.5V, -20°C ≤ T_C ≤ 100°C, N line wiring inductance less than 10nH (Note11)	I_C≤5A	3.0	-	-	
			5<I_C≤8.5A	3.5	-	-	
V_{NC}	V_{NC} variation	Between V_{NC}-NU, NV, NW (including surge)		-5.0	-	+5.0	V
T_j	Junction temperature			-20	-	+125	°C

Note 9: The allowable r.m.s. current value depends on the actual application conditions.
10: DIPIPM might not make response to the input on signal with pulse width less than PWIN (on).
11: IPM might make no response or delayed response (P-side IGBT only) for the input signal with off pulse width less than PWIN(off).
Please refer below figure about delayed response.

Fig. 4 About Delayed Response Against Shorter Input Off Signal Than PWIN(off) (P-side only)

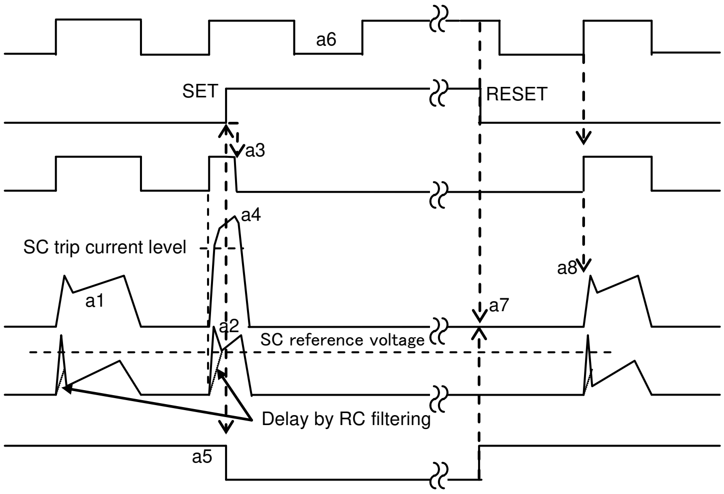


Solid line …Off pulse width ≥ PWIN(off);
Turn on time t1 (Normal delay)
Broken line …Off pulse width < PWIN(off);
Turn on time t2 (Longer delay in some cases)

Fig. 5 Timing Charts of DIPIPM Protective Functions

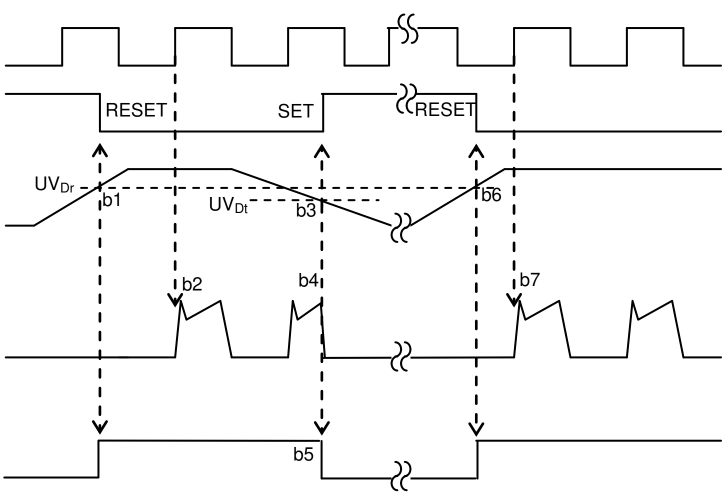
[A] Short-Circuit Protection (N-side only with the external sense resistor and RC filter)

a1. Normal operation: IGBT ON and outputs current.
a2. Short circuit current detection (SC trigger)
(It is recommended to set RC time constant 1.5~2.0μs so that IGBT shut down within 2.0μs when SC occurs.)
a3. All N-side IGBT's gates are hard interrupted.
a4. All N-side IGBTs turn OFF.
a5. F_O outputs with a fixed pulse width determined by the external capacitor C_{FO}.
a6. Input = “L”: IGBT OFF
a7. Fo finishes output, but IGBTs don't turn on until inputting next ON signal (L→H).
(IGBT of each phase can return to normal state by inputting ON signal to each phase.)
a8. Normal operation: IGBT ON and outputs current.



[B] Under-Voltage Protection (N-side, UV_D)

b1. Control supply voltage V_D exceeds under voltage reset level (UV_{Dr}), but IGBT turns ON by next ON signal (L→H).
(IGBT of each phase can return to normal state by inputting ON signal to each phase.)
b2. Normal operation: IGBT ON and outputs current.
b3. V_D level drops to under voltage trip level. (UV_{Dt}).
b4. All N-side IGBTs turn OFF in spite of control input condition.
b5. Fo outputs for the period determined by the capacitance $C_{FO,}$ but output is extended during V_D keeps below UV_{Dr}.
b6. V_D level reaches UV_{Dr}.
b7. Normal operation: IGBT ON and outputs current by next ON signal (L→H).



[C] Under-Voltage Protection (P-side, UV_{DB})

c1. Control supply voltage V_{DB} rises. After the voltage reaches under voltage reset level UV_{DBr}, IGBT turns on by next ON signal (L→H).
c2. Normal operation: IGBT ON and outputs current.
c3. V_{DB} level drops to under voltage trip level (UV_{DBt}).
c4. IGBT of corresponding phase only turns OFF in spite of control input signal level, but there is no F_O signal output.
c5. V_{DB} level reaches UV_{DBr}.
c6. Normal operation: IGBT ON and outputs current by next ON signal (L→H).

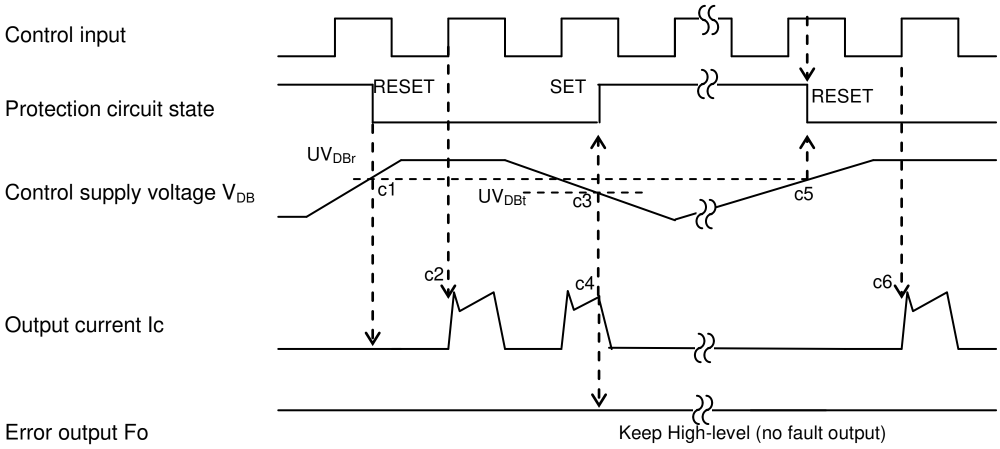
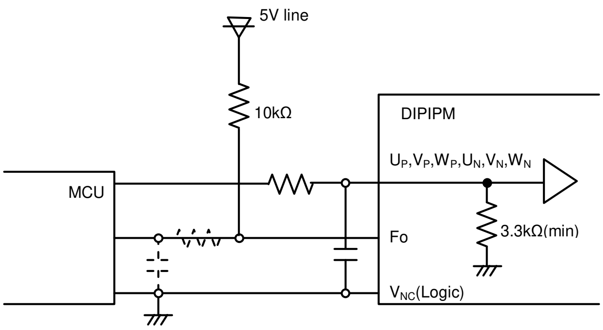
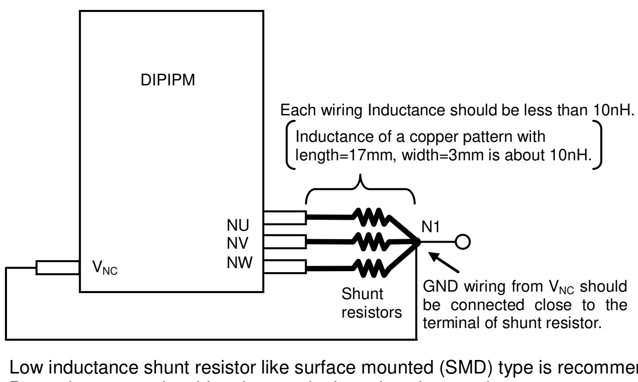


Fig. 6 MCU I/O Interface Circuit



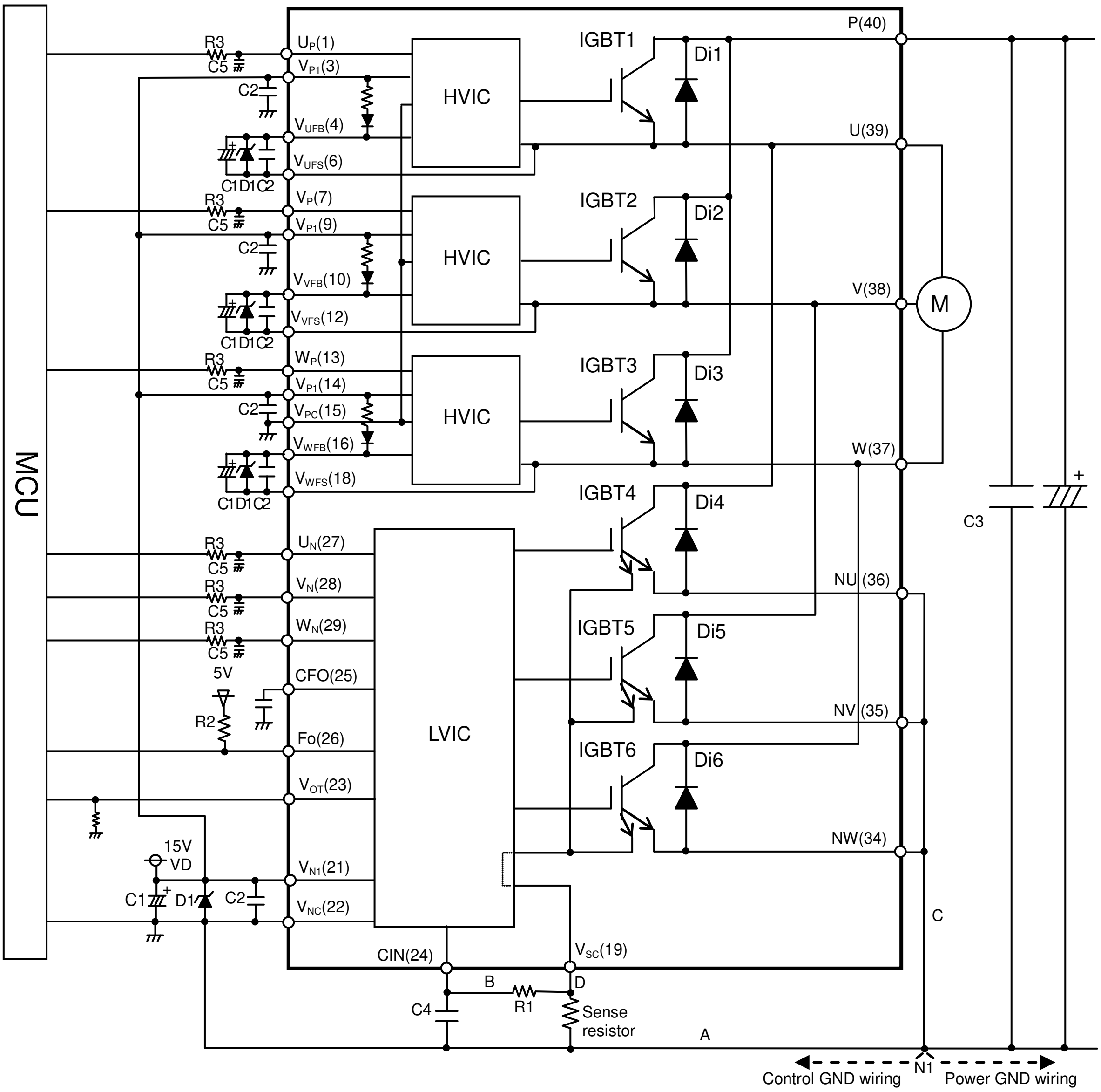
Note)
Design for input RC filter depends on the PWM control scheme used in the application and the wiring impedance of the printed circuit board.
But because noisier in the application for 1200V, it is strongly recommended to insert RC filter. (Time constant: over 100ns. e.g. 100Ω, 1000pF)
The DIPIPM input signal interface integrates a min. 3.3kΩ pull-down resistor. Therefore, when using RC filter, be careful to satisfy turn-on threshold voltage requirement.
Fo output is open drain type. It should be pulled up to the positive side of 5V or 15V power supply with the resistor that limits Fo sink current I_{Fo} under 1mA. In the case of pulling up to 5V supply, over 5.1kΩ is needed. (10kΩ is recommended.)

Fig. 7 Wiring Pattern around the Shunt Resistor in the Case of Inserting into Main Current Path



Low inductance shunt resistor like surface mounted (SMD) type is recommended.
Protection current level I_{SC} changes by inserting shunt resistor.

Fig. 8 Example of Application Circuit



Note

1 :If control GND and power GND are patterned by common wiring, it may cause malfunction by fluctuation of power GND level. It is recommended to connect control GND and power GND at only a N1 point at which NU, NV, NW are connected to power GND line.

2 :It is recommended to insert a Zener diode D1 (24V/1W) between each pair of control supply terminals to prevent surge destruction.

3 :To prevent surge destruction, the wiring between the smoothing capacitor and the P, N1 terminals should be as short as possible. Generally inserting a 0.1μ~0.22μF snubber capacitor C3 between the P-N1 terminals is recommended.

4 :R1, C4 of RC filter for preventing protection circuit malfunction is recommended to select tight tolerance, temp-compensated type. The time constant R1C4 should be set so that SC current is shut down within 2μs. (1.5μs~2μs is general value.) SC interrupting time might vary with the wiring pattern, so the enough evaluation on the real system is recommended. If R1 is too small, it may leads to delay of protection. So R1 should be min. 10 times larger resistance than Rs. (100 times is recommended.)

5 :To prevent erroneous operation, the wiring of A, B, C should be as short as possible.

6 :For sense resistor, the variation within 1%(including temperature characteristics), low inductance type is recommended. And the over 0.03W is recommended, but it is necessary to evaluate in your real system finally.

7 :To prevent erroneous SC protection, the wiring from V_{SC} terminal to CIN filter should be divided at the point D that is close to the terminal of sense resistor. And the wiring should be patterned as short as possible.

8 :All capacitors should be mounted as close to the terminals of the DIPIPM as possible. (C1: good temperature, frequency characteristic electrolytic type, and C2: 0.01μ~2.0μF, good temperature, frequency and DC bias characteristic ceramic type are recommended.)

9 :Input drive is High-active type. There is a min. 3.3kΩ pull-down resistor in the input circuit of IC. To prevent malfunction, the wiring of each input should be as short as possible. And it is recommended to insert RC filter (e.g. R3=100Ω and C5=1000pF) and confirm the input signal level to meet the turn-on and turn-off threshold voltage. Thanks to HVIC inside the module, direct coupling to MCU without any opto-coupler or transformer isolation is possible.

10 :Fo output is open drain type. Fo output will be max 0.95V(@I_{FO}=1mA,25℃), so it should be pulled up to MCU or control power supply (e.g. 5V,15V) by a resistor that makes I_{Fo} up to 1mA. (In the case of pulled up to 5V, 10kΩ is recommended.)

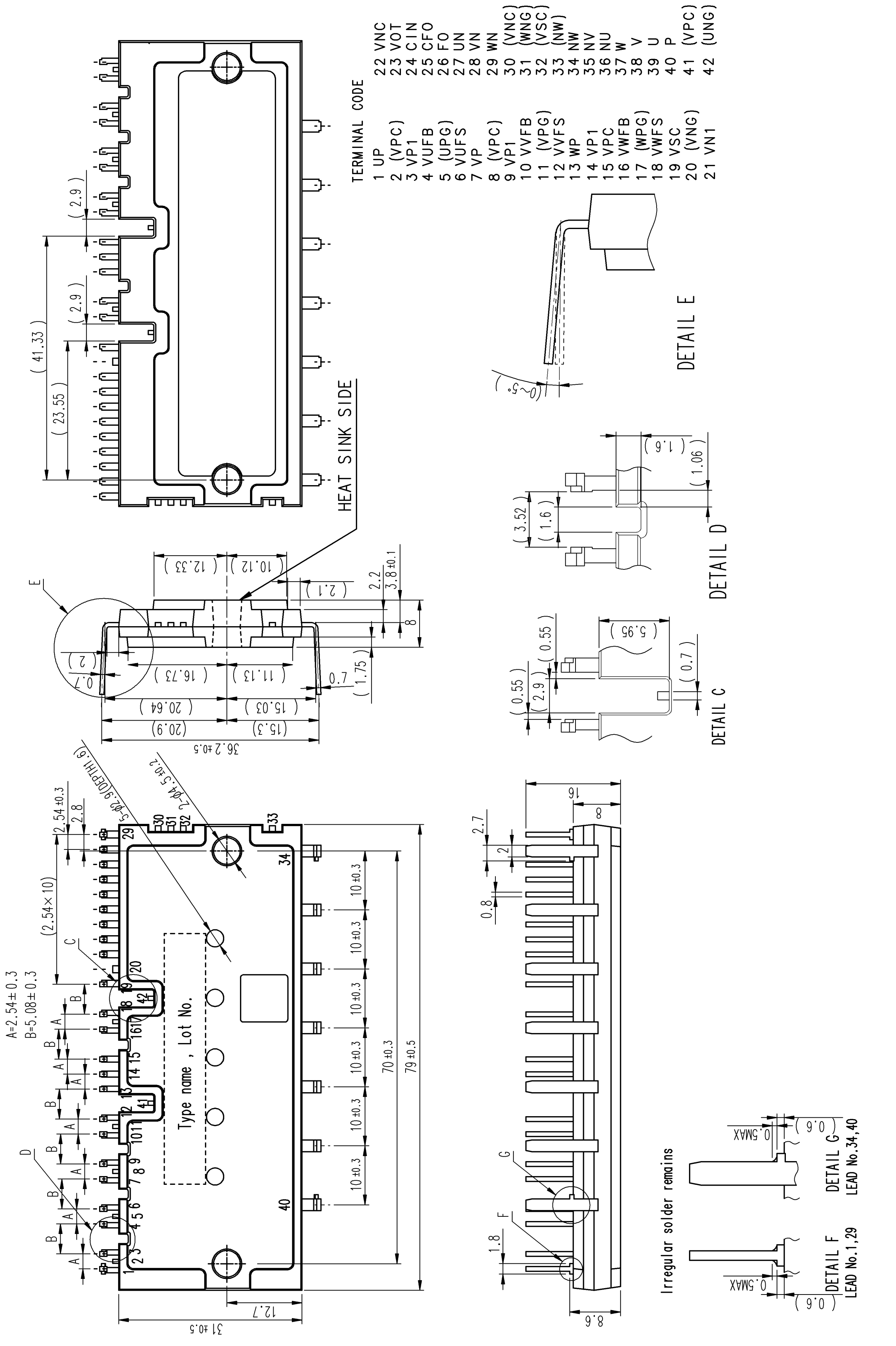
11 :Error signal output width (t_{Fo}) can be set by the capacitor connected to C_{FO} terminal. C_{FO}(typ.) = t_{Fo} x 9.1 x 10^{-6} (F)

12 :If high frequency noise superimposed to the control supply line, IC malfunction might happen and cause erroneous operation. To avoid such problem, voltage ripple of control supply line should meet dV/dt ≤+/-1V/μs, Vripple≤2Vp-p.

13 :For DIPIPM, it isn't recommended to drive same load by parallel connection with other phase IGBT or other DIPIPM.

Fig. 8 Package Outlines

Dimensions in mm



Revision Record

Rev.	Date	Page	Revised contents
1	13/03/2015	-	New

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