

MAXIMUM RATINGS ($T_j = 25^\circ\text{C}$, unless otherwise noted)**INVERTER PART**

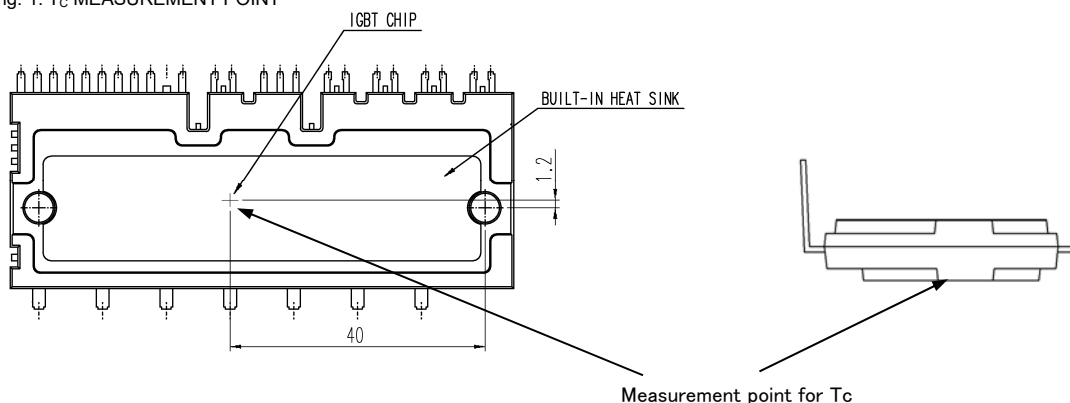
Symbol	Parameter	Condition	Ratings	Unit
V_{CC}	Supply voltage	Applied between P-NU, NV, NW	900	V
$V_{CC(\text{surge})}$	Supply voltage (surge)	Applied between P-NU, NV, NW	1000	V
V_{CES}	Collector-emitter voltage		1200	V
$\pm I_C$	Each IGBT collector current	$T_C = 25^\circ\text{C}$	35	A
$\pm I_{CP}$	Each IGBT collector current (peak)	$T_C = 25^\circ\text{C}$, up to 1ms	70	A
P_C	Collector dissipation	$T_C = 25^\circ\text{C}$, per 1 chip	129.9	W
T_j	Junction temperature		-20~+150	$^\circ\text{C}$

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	1	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
$V_{CC(\text{PROT})}$	Self protection supply voltage limit (Short circuit protection capability)	$V_D = 13.5\sim 16.5\text{V}$, Inverter Part $T_j = 125^\circ\text{C}$, non-repetitive, up to 2 μs	800	V
T_C	Module case operation temperature	(Note 1)	-20~+100	$^\circ\text{C}$
T_{stg}	Storage temperature		-40~+125	$^\circ\text{C}$
V_{ISO}	Isolation voltage	60Hz, Sinusoidal, AC 1min, between connected all pins and heat sink plate	2500	V_{rms}

Note 1: T_C measurement point is described in Fig.1.Fig. 1: T_C MEASUREMENT POINT**THERMAL RESISTANCE**

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$R_{th(l-c)Q}$	Junction to case thermal resistance (Note 2)	Inverter IGBT part (per 1/6 module)	-	-	0.77	K/W
$R_{th(l-c)F}$		Inverter FWDi part (per 1/6 module)	-	-	1.25	K/W

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

ELECTRICAL CHARACTERISTICS ($T_j = 25^\circ\text{C}$, unless otherwise noted)**INVERTER PART**

Symbol	Parameter	Condition	Limits			Unit
			Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_D=V_{DB} = 15\text{V}$, $V_{IN}= 5\text{V}$, $I_C= 35\text{A}$	-	1.90	2.60	V
		$T_j= 125^\circ\text{C}$	-	2.00	2.70	
V_{EC}	FWDi forward voltage	$V_{IN}= 0\text{V}$, $-I_C= 35\text{A}$	-	2.20	2.80	V
t_{on}	Switching times	$V_{CC}= 600\text{V}$, $V_D= V_{DB}= 15\text{V}$ $I_C= 35\text{A}$, $T_j= 125^\circ\text{C}$, $V_{IN}= 0 \leftrightarrow 5\text{V}$ Inductive Load (upper-lower arm)	0.50	1.20	1.90	μs
$t_{C(on)}$			-	0.60	0.90	μs
t_{off}			-	2.40	3.50	μs
$t_{C(off)}$			-	0.60	0.90	μs
t_{tr}			-	0.50	-	μs
I_{CES}	Collector-emitter cut-off current	$V_{CE}=V_{CES}$	-	-	1	mA
		$T_j= 125^\circ\text{C}$	-	-	10	

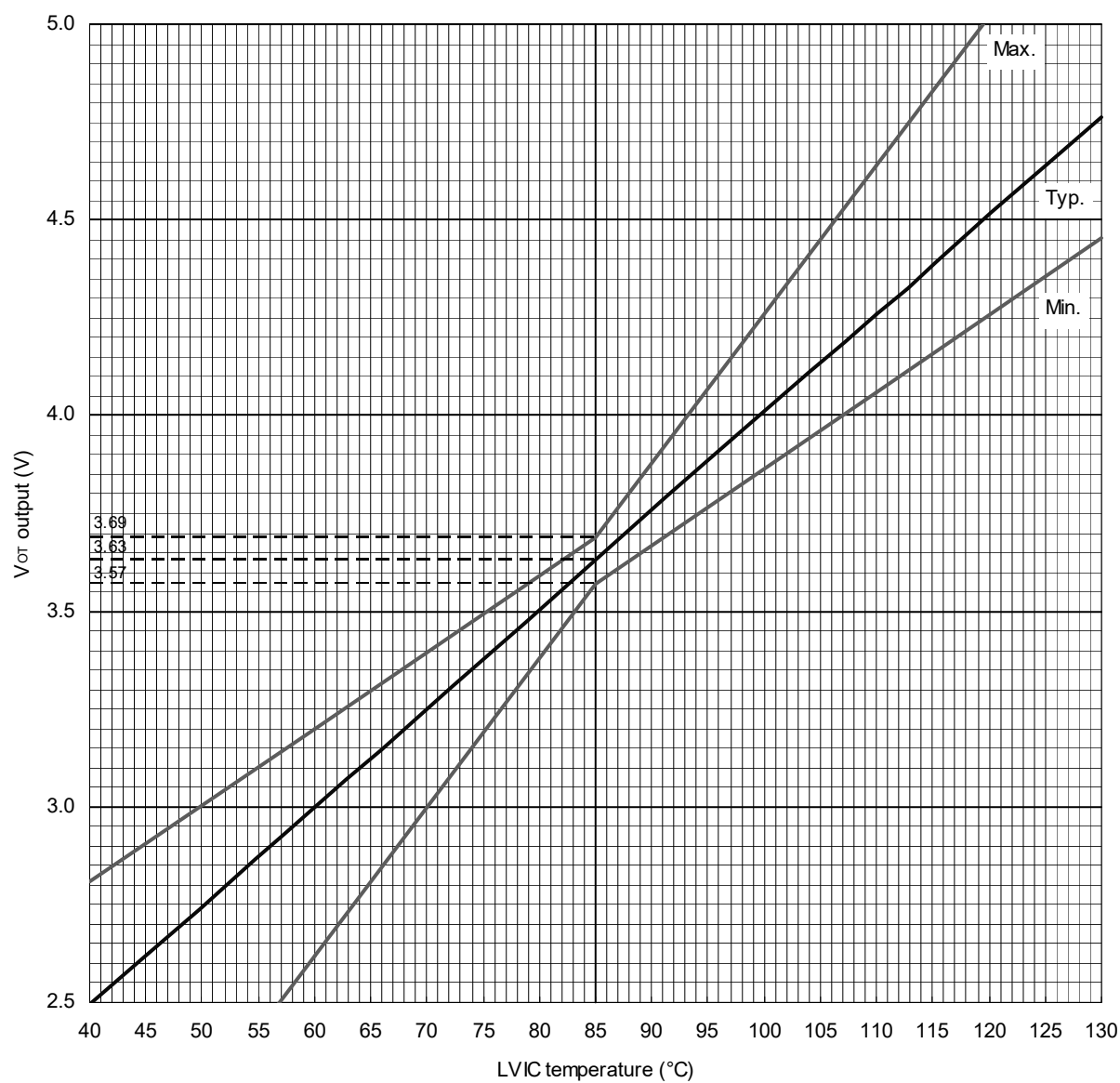
CONTROL (PROTECTION) PART

Symbol	Parameter	Condition		Limits			Unit	
				Min.	Typ.	Max.		
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 _D =V _{DB} =15V, V _{IN} =0V	-	-	1.10		
			V _D =V _{DB} =15V, V _{IN} =5V	-	-	1.10		
I _{SC}	Short circuit trip level	-20°C≤T _j ≤125°C, R _S = 48.7Ω (±1%), Not connecting outer shunt resistors to NU,NV,NW terminals (Note 3)		59.5	-	-	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 = 85°C (Note 5)			3.57	3.63	3.69	V

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 DIIPM.

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} . ($C_{FO}(\text{typ.}) = t_{FO} \times (9.1 \times 10^{-6}) [\text{F}]$)

5: DIIPM 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 the DIIPM immediately. This output might exceed 5V when temperature rises excessively, so it is recommended to insert a clamp Di between controller supply (e.g. 5V) and V_{OT} output for overvoltage protection. Temperature of LVIC vs. V_{OT} output characteristics is described in Fig.2

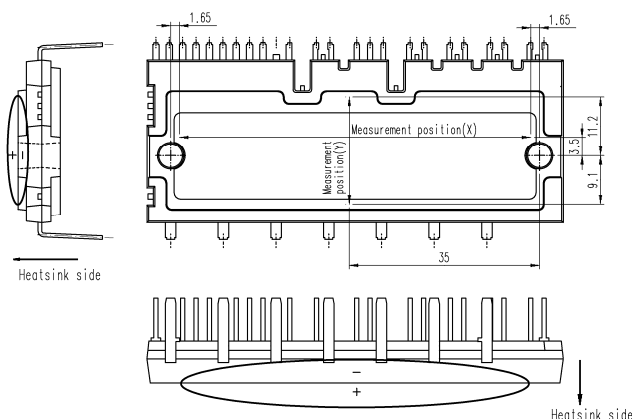
Fig. 2 Temperature of LVIC vs. V_{OT} Output Characteristics

Please refer the application note about the usage of V_{OT} too.

MECHANICAL CHARACTERISTICS AND RATINGS

Parameter	Condition		Limits			Unit
			Min.	Typ.	Max.	
Mounting torque	Mounting screw : M4	Recommended 1.18N·m	0.98	1.18	1.47	N·m
Terminal pulling strength	Load 19.6N	JEITA-ED-4701	10	-	-	s
Terminal bending strength	Load 9.8N, 90deg. bend	JEITA-ED-4701	2	-	-	times
Weight			-	46	-	g
Heat-sink flatness		(Note 6)	-50	-	100	μm

Note 6: 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 ≤ 100°C, T _J ≤ 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 ≤ 100°C, T _J ≤ 125°C (Note 7)	f _{PWM} = 5kHz	-	-	19.1	Arms
			f _{PWM} = 15kHz	-	-	12.8	
PWIN(on)	Minimum input pulse width	(Note 8)		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 (Note 9)	I _C ≤ 35A	2.3	-	-	
			35A < I _C ≤ 59.5A	2.9	-	-	
V _{NC}	V _{NC} variation	Between V _{NC} -NU, NV, NW (including surge)		-5.0	-	+5.0	V
T _i	Junction temperature			-20	-	+125	°C

Note 7: The allowable r.m.s. current value depends on the actual application conditions.

8: DIIPIM might not make response to the input on signal with pulse width less than PWIN (on).

9: 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 Fig. 3 about delayed response.

Fig. 3 About Delayed Response Against Shorter Input Off Signal Than PWIN(off) (P-side only)

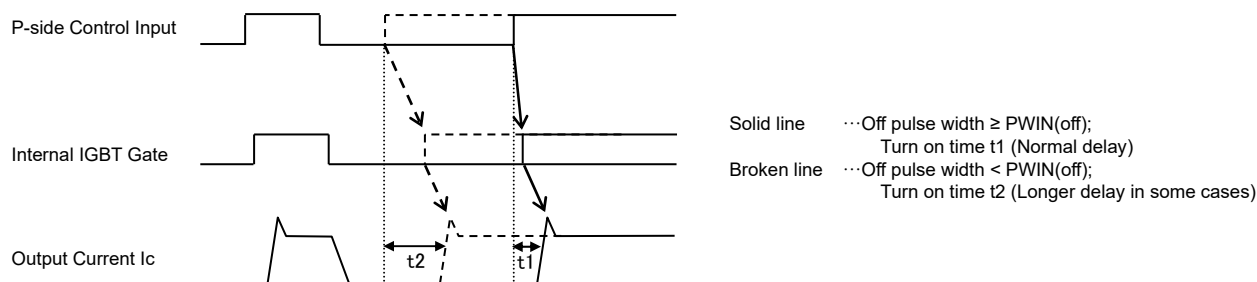
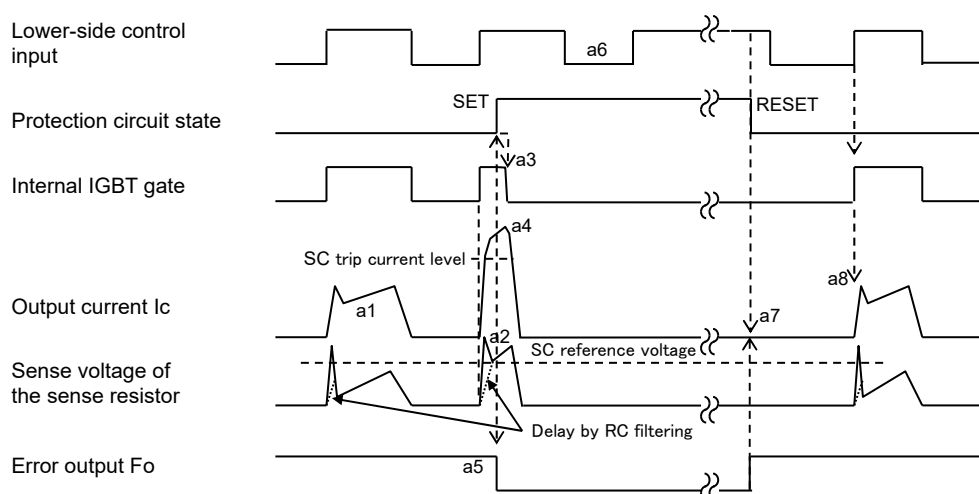


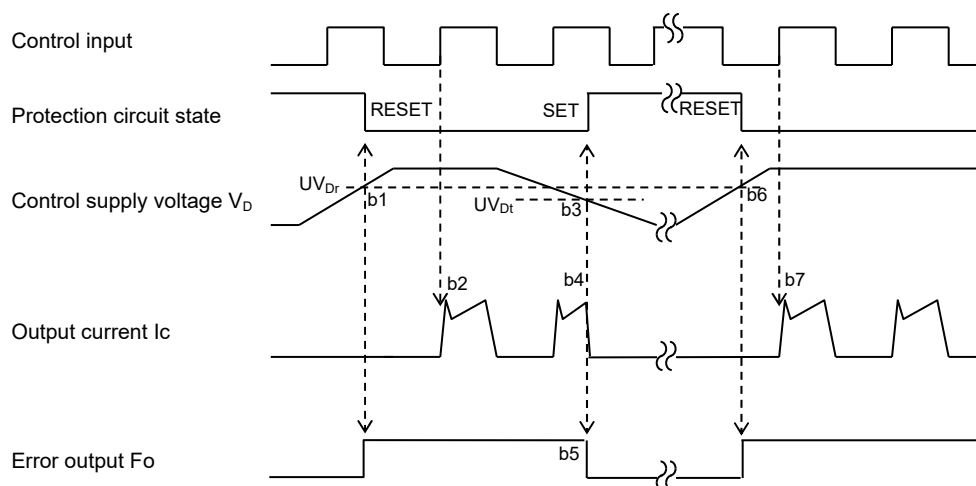
Fig. 4 Timing Charts of DIIPM Protective Functions

[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 1.5~2.0 μ s so that IGBT shut down within 2.0 μ s 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. F_O finishes output, but IGBTs don't turn on until inputting next ON signal (L \rightarrow 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 \rightarrow 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. F_O 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 \rightarrow 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).

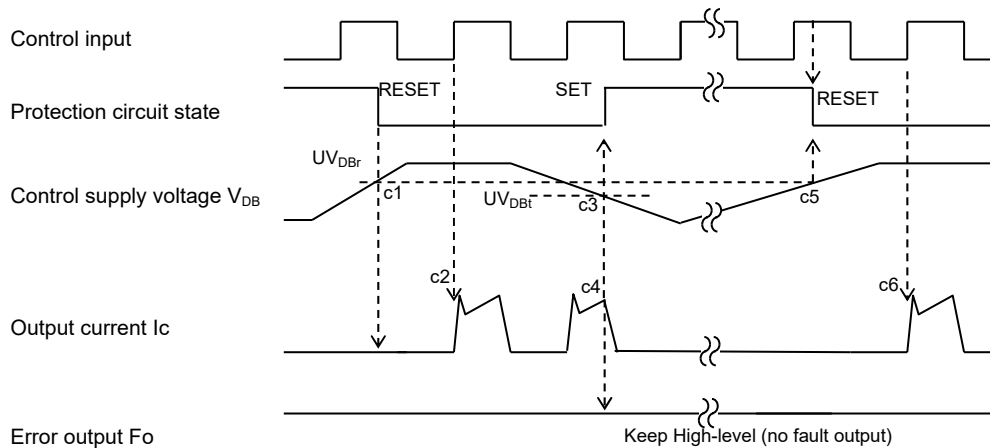
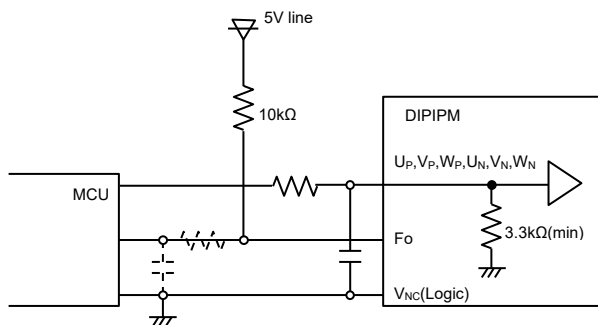


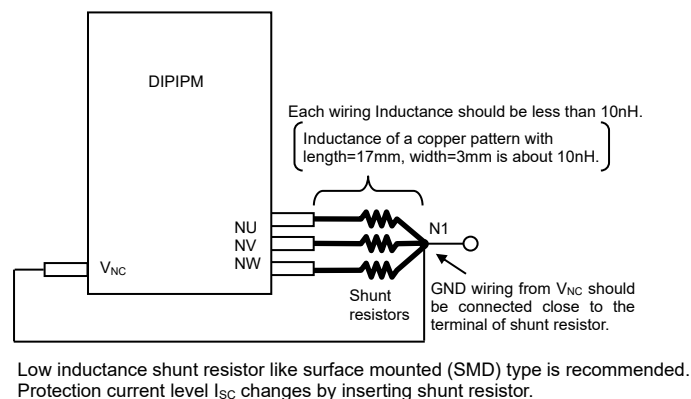
Fig. 5 MCU I/O Interface Circuit

**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.

F_o 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 I_{F_o} under 1mA. In the case of pulling up to 5V supply, over 5.1kΩ is needed. (10kΩ □ is recommended.)

Fig. 6 Wiring Pattern around the Shunt Resistor in the Case of Inserting into Main Current Path



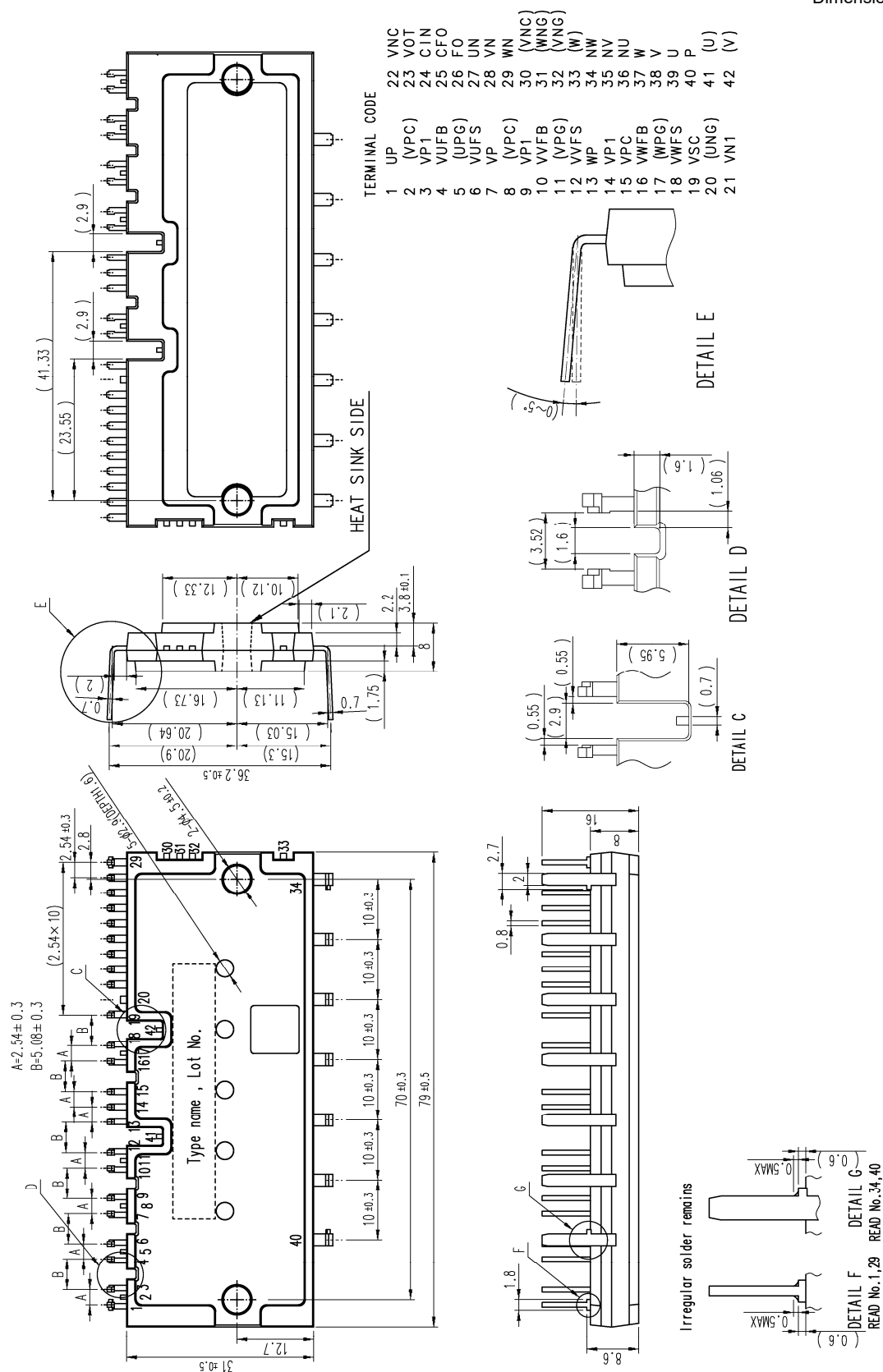
The schematic diagram illustrates a motor driver circuit. On the left, an MCU is connected to various pins of the HVICs and LVIC. The HVICs (High Voltage Integrated Circuits) are connected to the IGBTs (Insulated Gate Bipolar Transistors) and diodes (Di1-Di6). The LVIC (Low Voltage Integrated Circuit) is connected to the IGBTs and provides a sense voltage (Vsc) to the MCU. The motor (M) is connected to the IGBTs and diodes. The circuit is powered by a 15V supply (V_D) and a 5V supply. Grounding is shown for Control GND and Power GND. The sense voltage (Vsc) is measured across a sense resistor (R_s) and is connected to the MCU via a sense line (A). The motor is connected to the IGBTs and diodes, and its ground is connected to the Power GND.

- 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 1/8W 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: 0.22μ~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 strongly 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. 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. (I_{Fo} is estimated roughly by the formula of control power supply voltage divided by pull-up resistance. In the case of pulled up to 5V, 10kΩ (5kΩ or more) 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} × (9.1 × 10⁻⁶) (F)
- 12: High voltage (V_{RRM} =1200V or more) and fast recovery diode (trr=less than 100ns or less) should be used for D2 in the bootstrap circuit.
- 13: 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, Vripples≤2Vp-p.
- 14: For DIPIPM, it isn't recommended to drive same load by parallel connection with other phase IGBT or other DIPIPM.

PS22A78-ETRANSFER MOLDING TYPE
INSULATED TYPE

Fig. 8 Package Outlines

Dimensions in mm



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