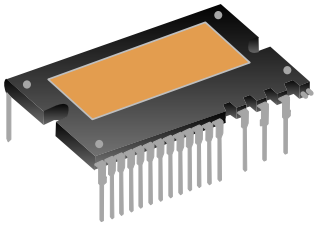
600V/15A 3-PHASE FULL-BRIDGE DRIVER (INTELLIGENT POWER MODULE)

DESCRIPTION

SDM15G60FB is a 3-phase brushless DC motor driver with high integration and high reliability for low power inverter driving such as air conditioner, refrigerator and dishwasher. It has embedded six low-loss IGBTs and 3-phase full-bridge gate drivers with high voltage.

The under voltage, short circuit and over temperature protections integrated make the circuit work safely in a wide range. The current of each phase can be detected separately because there is one independent negative DC terminal for each phase.

SDM15G60FB uses high-insulation design, compact package and carries heat easily, which makes it easy to use especially for compact installation applications.



DIP-24HL

FEATURES

- Built-in low-loss 600V/15A IGBT;
- Built-in high-voltage integrated circuit of gate driver;
- Built-in under voltage protection, over temperature protection, over current protection and temperature output;
- Built-in bootstrap diode with current limiting resistor;
- Compatible with 3.3V, 5V MCU interface, active high;
- Three independent negative DC terminal for inverter current detection;
- Alarm signal: for low-side under voltage, over temperature and short circuit protections;
- Very low thermal resistance using Al_2O_3 DBC substrate;
- Insulation level: 1500Vrms/min

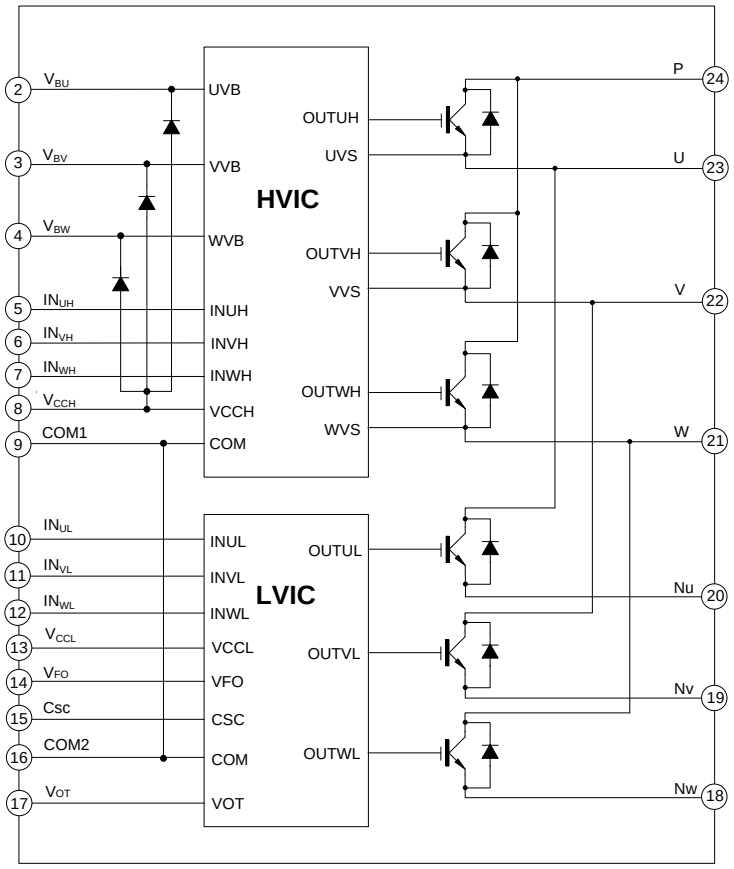
APPLICATIONS

- Air conditioner compressor
- Refrigerator compressor
- Low power inverter

ORDERING INFORMATION

Part No.	Package	Marking	Hazardous Substance Control	Packing
SDM15G60FB	DIP-24HL	SDM15G60FB	Halogen free	Tube

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATING

Characteristics	Symbol	Rating	Unit
Inverter section			
Voltage on the DC bus between PN	V_{PN}	450	V
Surge voltage on the DC bus between PN	$V_{PN(Surge)}$	500	V
Voltage between collector and emitter	V_{CES}	600	V
Continuous current of the single IGBT collector, T_C=25°C, Tj<150°C	I_C	15	A
Peak current of the single IGBT collector, T_C=25°C, Tj<150°C, Pulse width less than 1ms	I_{CP}	30	A
Max. power dissipation of the collector of each module, T_C=25°C	P_C	35	W
Control section			
Control supply voltage	V_{CC}	20	V
High-side control voltage	V_{BS}	20	V
Input signal voltage	V_{IN}	-0.5~ V_{CC}+0.5	V
Fault output supply voltage	V_{FO}	-0.5~V_{CC}+0.5	V

Characteristics	Symbol	Rating	Unit
Fault output current Sink current at V_{FO} pin	I_{FO}	1	mA
Input voltage at current detect pin	V_{SC}	-0.5~V_{CC}+0.5	V
Whole system			
Voltage limit of short circuit protection V_{CC}=V_{BS}=13.5~16.5V, T_J=150°C, single and less than 2μs	$V_{PN(PROT)}$	400	V
Operating temperature of module case Limit condition: -40°C≤T_J≤150°C (Note 1)	T_C	-20~100	°C
Storage temperature range	T_{STG}	-40~125	°C
Junction-to-case thermal resistance of each IGBT	$R_{\theta JCQ}$	3.0	°C/W
Junction-to-case thermal resistance of each FRD	$R_{\theta JCF}$	3.9	°C/W
Insulation voltage 60Hz, Sine, 1 minute Connect the pin to heatsink	V_{ISO}	1500	V_{rms}
Mounting torque Mounting screws: -M3, 0.62N.m recommended	T	0.5~0.8	N.m

Note 1: The maximum junction temperature rating of power chip is 150°C (@Tc≤100°C).To ensure safe operation of IPM, the average junction temperature should be limited to Tj(ave)≤125°C(@Tc≤100°C)

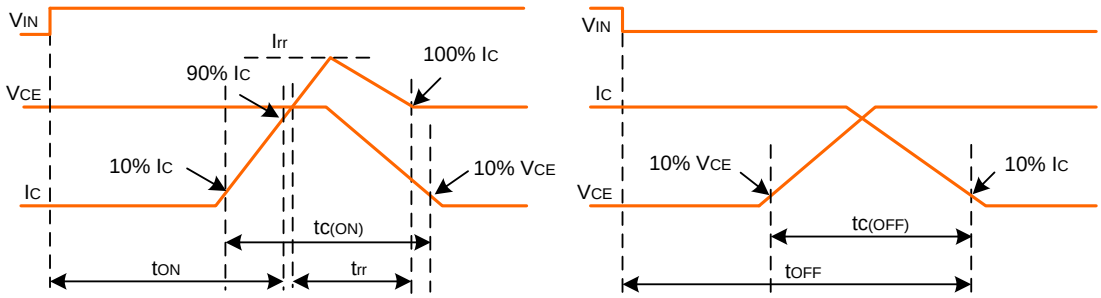
RECOMMENDED OPERATING CONDITIONS

Characteristics	Symbol	Ratings			Unit
		Min.	Typ.	Max.	
Voltage on the bus between PN	V_{PN}	-	300	400	V
Control supply voltage	V_{CC}	13.5	15	16.5	V
High-side control voltage	V_{BS}	13.5	15	18.5	V
Control voltage variation	dV_{CC}/dt dV_{BS}/dt	-1	-	1	V/μs
On threshold voltage	$V_{IN(ON)}$	3.0	-	V_{CC}	V
Off threshold voltage	$V_{IN(OFF)}$	0	-	0.6	V
Blanking time for preventing Arm-short	T_{dead}	1.0	-	-	μs
PWM input signal	f_{PWM}	-	-	20	KHz
COM variation (Between COM-Nu,Nv,Nw)	V_{COM}	-5	-	5	V

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Tamb=25°C, V_{CC}=V_{BS}=15V)

Inverter part

Characteristics		Symbol	Conditions	Min.	Typ.	Max.	Unit
Saturation voltage between collector and emitter		$V_{CE(SAT)}$	V_{CC}=V_{BS}=15V, V_{IN}=5V I_C=15A, T_J = 25°C	-	1.8	2.3	V
FRD forward voltage		V_F	V_{IN}=0V, I_F=15A, T_J = 25°C	-	1.8	2.3	V
Switching times	High side	t_{ON}	V_{PN} = 300V, V_{CC} = V_{BS} = 15V, I_C = 15A, V_{IN} = 0V←→ 5V, Inductive load Refer to fig. 1	-	0.95	-	μs
		$t_{C(ON)}$		-	0.40	-	μs
		t_{OFF}		-	0.95	-	μs
		$t_{C(OFF)}$		-	0.15	-	μs
		t_{rr}		-	0.06	-	μs
	Low side	t_{ON}		-	0.85	-	μs
		$t_{C(ON)}$		-	0.40	-	μs
		t_{OFF}		-	0.85	-	μs
		$t_{C(OFF)}$		-	0.15	-	μs
		t_{rr}		--	0.06	-	μs
Leakage current between collector and emitter		I_{CES}	V_{CE}=V_{CES}	-	-	1	mA



(a)On period (b)Off period

Figure.1. Switching definition

Control part

Characteristics	Symbol	Conditions		Min.	Typ.	Max.	Unit
V_{CC} Quiescent current	I_{QCCN}	V_{CC}=15V, V_{IN}=5V	V_{CCH}-COM, V_{CCL}-COM	-	-	2.8	mA
	I_{QCCF}	V_{CC}=15V, V_{IN}=0V		-	-	2.8	mA
V_{BS} Quiescent current	I_{QBS}	V_{BS}=15V, V_{INH}=0V	V_{BU}-V_{SU}, V_{BV}-V_{SV}, V_{BW}- V_{SW}	-	-	100	μA
Fault output voltage	V_{FOH}	V_{SC}=0V, V_{FO} pull up 10KΩ resistor to 5V		4.9	-	-	V
	V_{FOL}	V_{SC}=1V,IFo=1mA		-	-	0.95	V
Fault output pulse width	t_{FO}	(note2)		20	-	-	us
Trip voltage of short circuit(fig.5)	$V_{SC(ref)}$	V_{CC}=15V (note3)		0.43	0.48	0.53	V

Characteristics	Symbol	Conditions		Min.	Typ.	Max.	Unit
Over-temperature protection(fig.8)	TSD	LVIC temperature		100	120	140	°C
Over-temperature protection hysteresis	ΔTSD	LVIC Hysteresis temperature		-	10	-	°C
Temperature output(fig.3)	V_{OT}	LVIC temperature=25°C		0.88	1.13	1.39	V
		LVIC temperature=90°C		2.63	2.77	2.91	V
Low-side under voltage protection(fig.6)	UV_{CCD}	V_{CC} detect voltage		10.5	11.5	12.5	V
	UV_{CCR}	V_{CC} reset voltage		11.0	12.0	13.0	V
High-side under voltage protection (fig.7)	UV_{BSD}	V_{BS} detect voltage		9.0	10.0	11.0	V
	UV_{BSR}	V_{BS} reset voltage		9.5	10.5	11.5	V
On threshold voltage	V_{IH}	Logic High	Between input and COM	-	2.1	2.6	V
Off threshold voltage	V_{IL}	Logic Low		0.8	1.3	-	V

Note2: Fault signal FO outputs when short circuit, over temperature or under voltage protection works. And FO pulse width is different for each protection modes. When the short circuit or over temperature happens, FO pulse width is a fixed width (=min.20us), but when the under voltage happens, FO outputs continuously until recover from under voltage state. (But the minimum FO pulse width is 20us)

Note3: Short circuit protection only works when the low-sides detected short circuit.

Bootstrap Diode Part (Each Bootstrap diode, Unless Otherwise Specified)

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Forward Voltage	V_F	I_F=0.1A, T_C=25°C	-	10.7	-	V
Reverse Recovery Time	t_{rr}	I_F=0.1A, T_C=25°C	-	80	-	ns

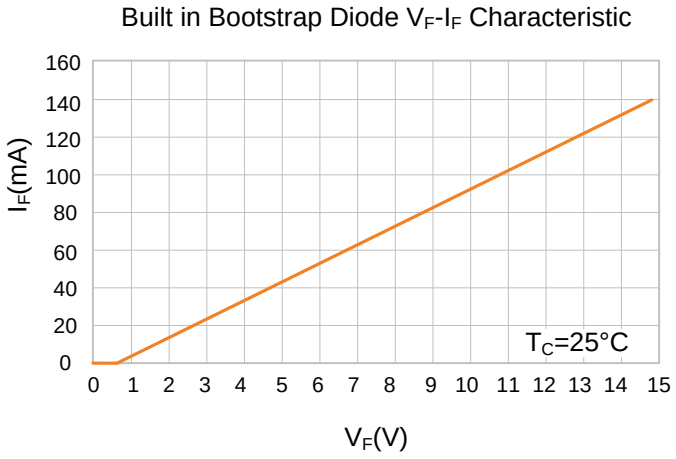
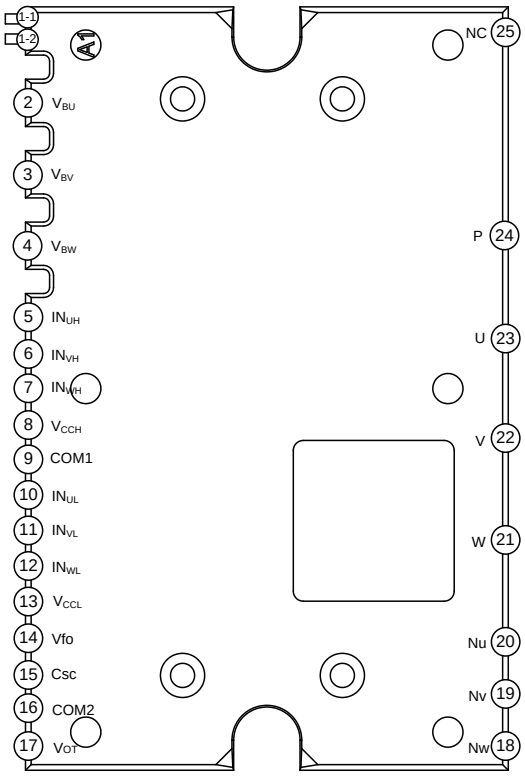


Figure.2. Built in bootstrap diode characteristic curve

Note: Resistive characteristic: equivalent resistor: ~100Ω.

PIN CONFIGURATION



PIN DESCRIPTION

Pin No.	Pin Name	Pin Descriptions
1-1	(Com)	Inner used terminal, it has control GND potential, should be left no connection
1-2	(Vcc)	Inner used terminal, it has control supply potential, should be left no connection
2	V_{BU}	Floating supply voltage for U-phase high-side IGBT driving
3	V_{BV}	Floating supply voltage for V-phase high-side IGBT driving
4	V_{BW}	Floating supply voltage for W-phase high-side IGBT driving
5	IN_{UH}	U-phase high-side signal input
6	IN_{VH}	V-phase high-side signal input
7	IN_{WH}	W-phase high-side signal input
8	V_{CCH}	Supply voltage for high-side gate driver
9	Com1	Common ground for the module
10	IN_{UL}	U-phase low-side signal input
11	IN_{VL}	V-phase low-side signal input
12	IN_{WL}	W-phase low-side signal input
13	V_{CCL}	Supply voltage for low-side gate driver
14	V_{FO}	Fault output
15	Csc	Connect to the capacitor for short circuit current detection input and low-pass filter
16	Com2	Common ground for the module
17	V_{OT}	Temperature output

Pin No.	Pin Name	Pin Descriptions
18	N_W	W-phase DC negative terminal
19	N_V	V-phase DC negative terminal
20	N_U	U-phase DC negative terminal
21	W	W-phase output
22	V	V-phase output
23	U	U-phase output
24	P	DC positive terminal
25	NC	No connection

FUNCTION DESCIPTION OF TEMPERATURE OUTPUT

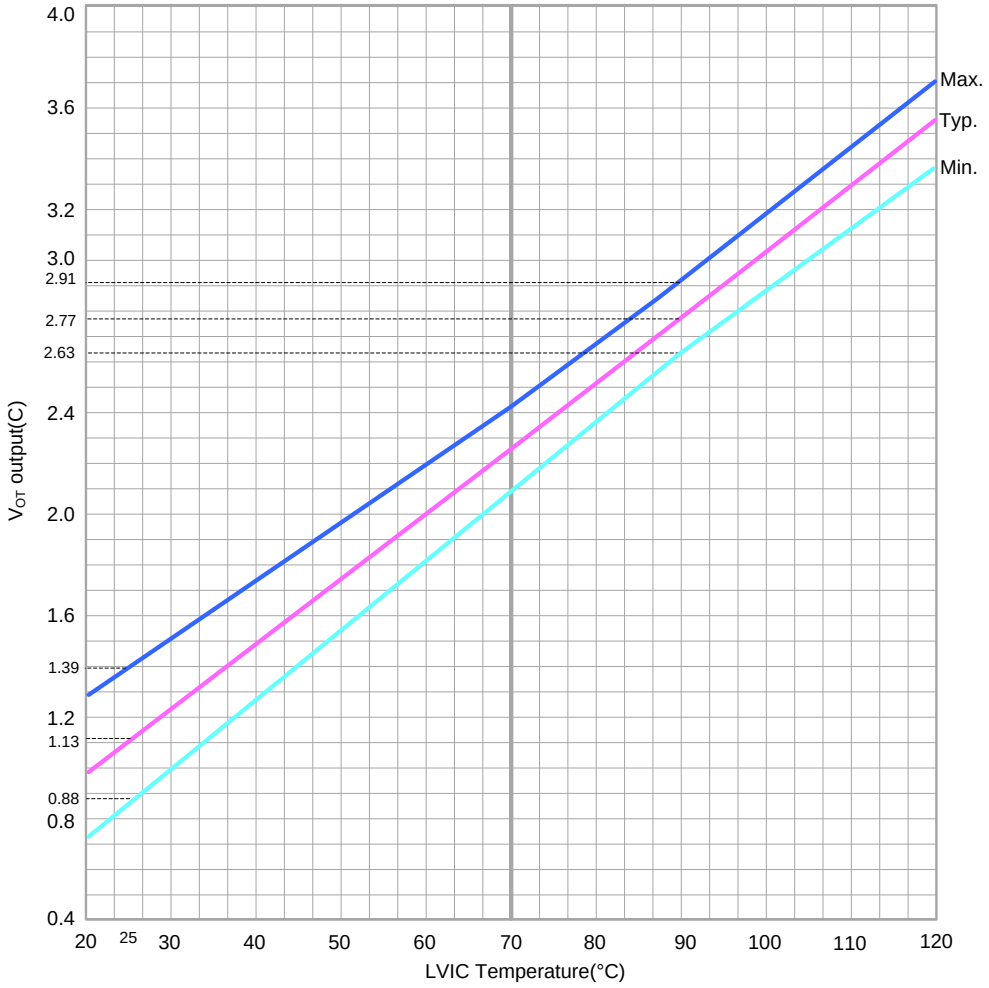


Figure 3. Temperature of LVIC vs. VOT output characteristics

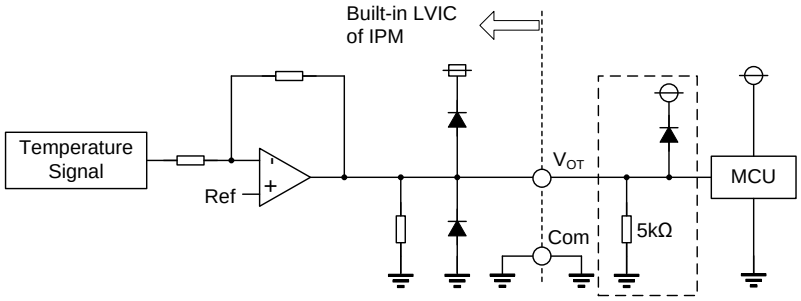


Figure 4: VOT output circuit

(1) It is recommended to insert a 5kΩ pull down resistor or above (5.1kΩrecommended) for realizing linear output characteristics at low temperature environment (below room temperature). When the pull down resistor is inserted between V_{OT} and Com (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, the pull down resistor is not needed.
(2) In low voltage control application (like 3.3V MCU), V_{OT} output might exceed control supply voltage 3.3V when temperature rises excessively. If system uses low voltage controller, it is recommended to insert a clamp diode between control supply of the controller and V_{OT} output for preventing over voltage destruction.
(3) If V_{OT} is not used, leave V_{OT} output NC (No Connection).

CONTROL TIMING SEQUENCE DESCRIPTION

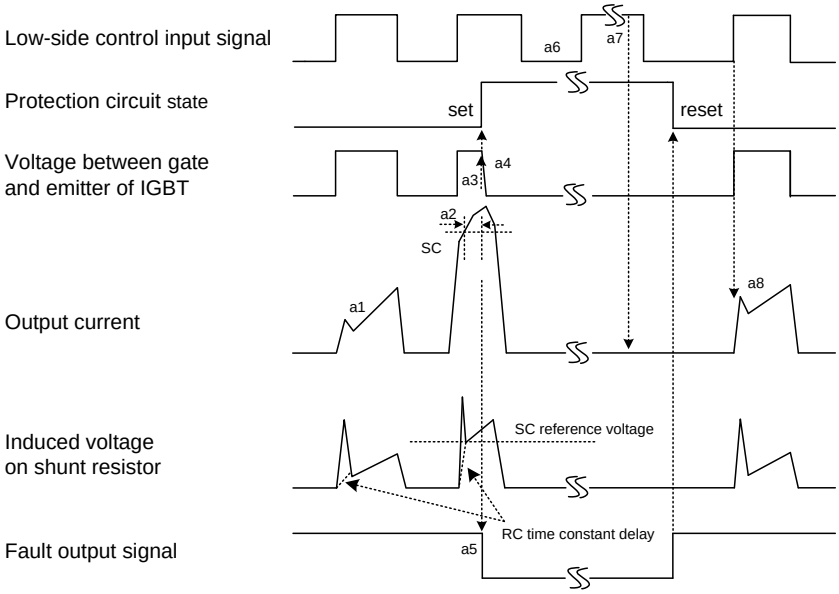


Figure. 5:Short circuit current protection(only for low-side)

(Including the external shunt resistor and RC connection)
a1: Normal operation: IGBT on and carrying current.
a2: Short circuit current detection (SC trigger).
a3: All low-side IGBT gate hard interrupt.
a4: All low-side IGBT turn off.
a5: Fault output with a fixed pulse width of t_{FO}=minimum 20us.
a6: Input ="L": IGBT off state.
a7: Input ="H": IGBT off state in spite of “H” input.
a8: Normal operation: IGBT turn on and carrying current.

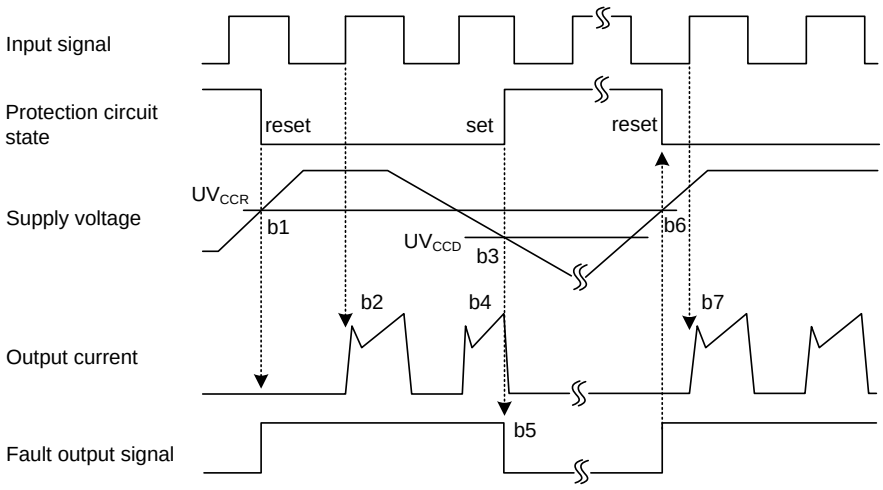


Figure.6:Under voltage protection(low-side)

b1: Supply voltage rises to UV_{CCR}, the circuit start to operate when next input is applied.

b2: Normal operation: IGBT turn on and carrying current.

b3: Under voltage detect point (UV_{CCD}).

b4: All low-side IGBT turn off in spite of control input condition.

b5: Fo output for t_{FO}=minimum 20us, but output is extended during supply voltage below UV_{CCR}.

b6: Under voltage reset (UV_{CCR}).

b7: Normal operation: IGBT turn on and carrying current.

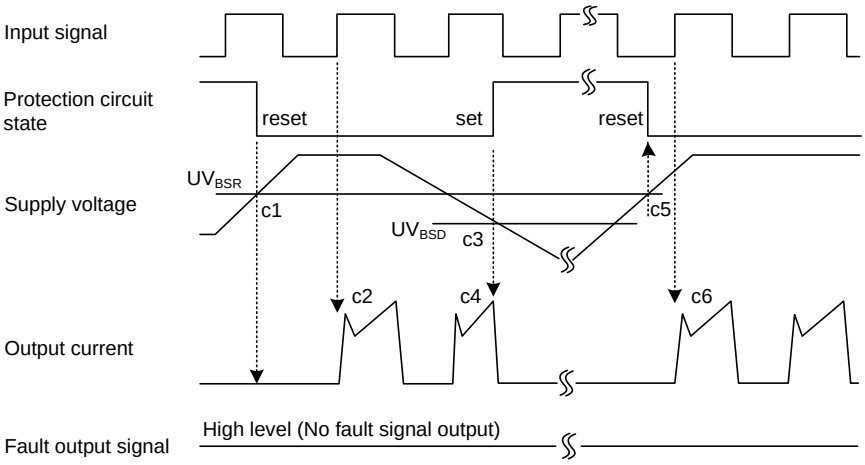


Figure.7:Under voltage protection(high-side)

c1: Supply voltage rises to UV_{BSR}, the circuit start to operate when next input is applied.

c2: Normal operation: IGBT turn on and carrying current.

c3: Under voltage detect (UV_{BSD}).

c4: IGBT turn off in spite of control input condition, but there is no fault output signal.

c5: Under voltage reset (UV_{BSR}).

c6: Normal operation: IGBT turn on and carrying current.

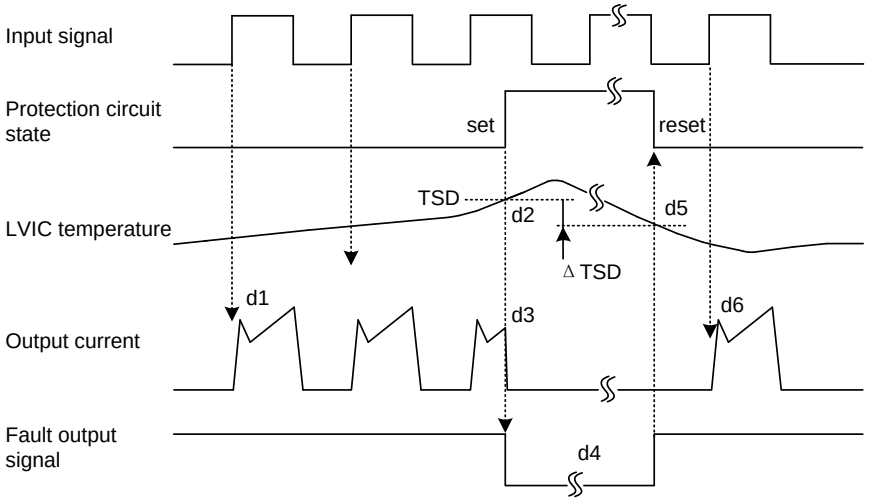


Figure.8:Over temperature protection(low-side)

d1：Normal operation: IGBT on and carrying current.
d2：LVIC temperature exceed over temperature trip lever (TSD).
d3：All low side IGBTs turn off in spite of control condition.
d4：Fo outputs during over temperature period, however, the minimum pulse width is 20us
d5：LVIC temperature becomes under over temperature reset lever.
d6：Circuits start to operate normally when the next input is applied.

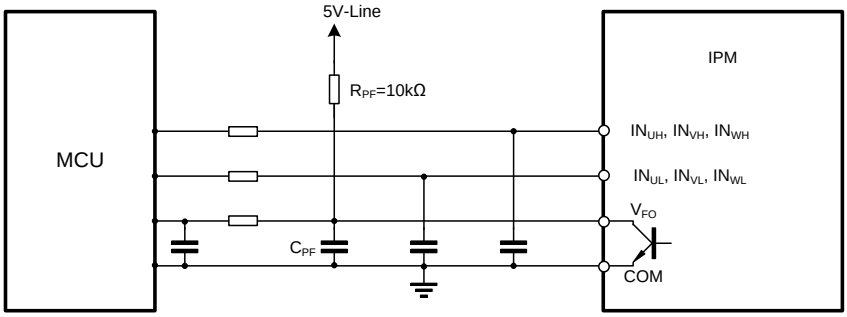
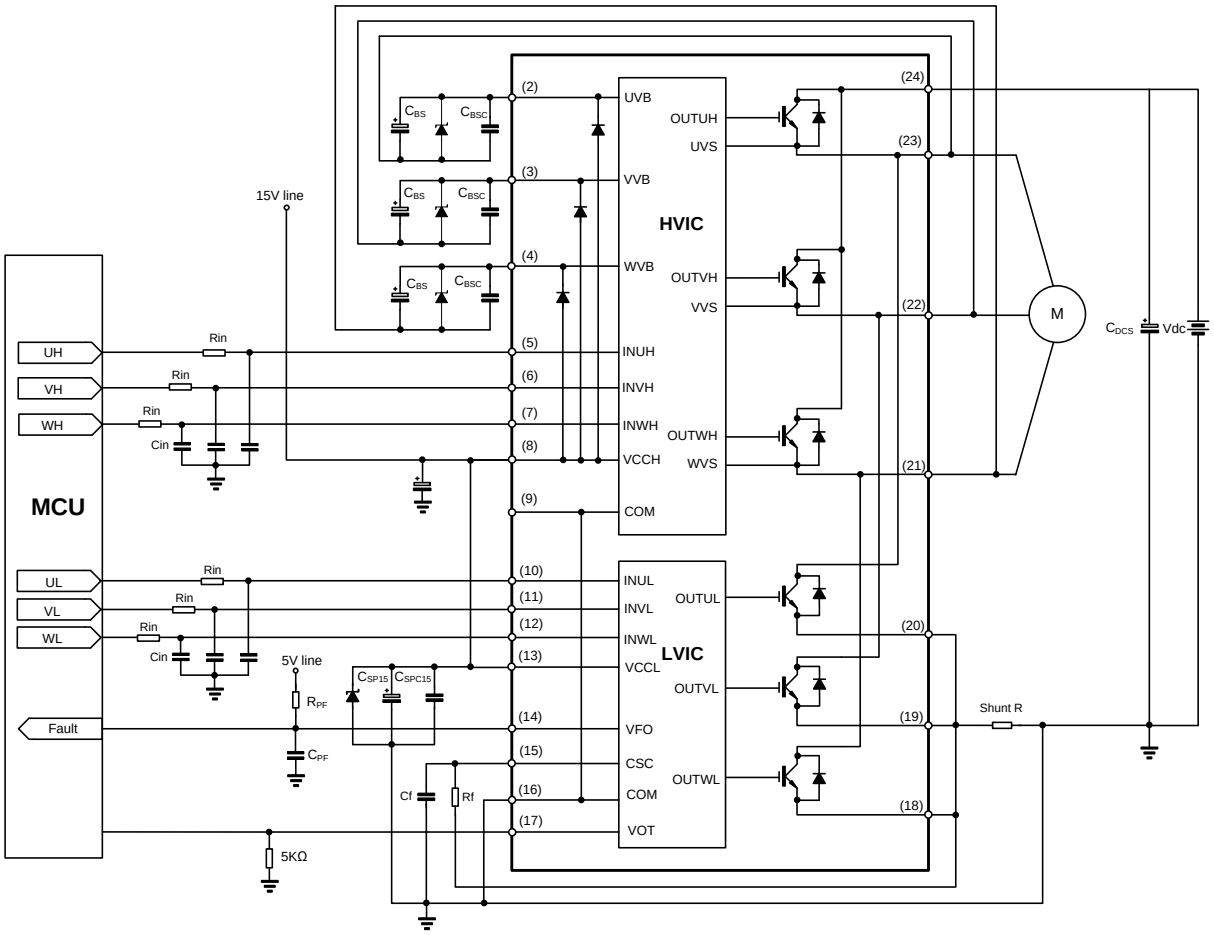


Figure. 9:MCU input/output connection circuit recommended

Note:

The RC coupling of each input should change following the PWM control solution and the PCB connection impedance. There is a 5K pull-down resistor integrated in IPM input signal section, so, should pay attention on the voltage drop at input terminal when using an external filter resistor.

TYPICAL APPLICATION CIRCUIT



Note:

(1) The routing of each input pin should be as short as possible to avoid the possible malfunction;

(2) Input signal is active-high type and there is a 5KΩ resistor inside the HVIC to pull down each input signal line to the ground. In addition, RC filter circuit can be added to the input which will prevent the surge noise caused by the incorrect input.

(3) To avoid the surge damage, a flat high-frequency non-inductive capacitor between 0.1μF and 0.22μF should be connected between PN and the routing must be as short as possible;

(4) The routing between current detect resistor and IPM should be as short as possible to avoid the damage caused by the big surge voltage bringing from the connection inductance.

(5) The 15V input power supply should be added a filter capacitor and its capacitance at least should be 7 times as of bootstrap capacitor's;

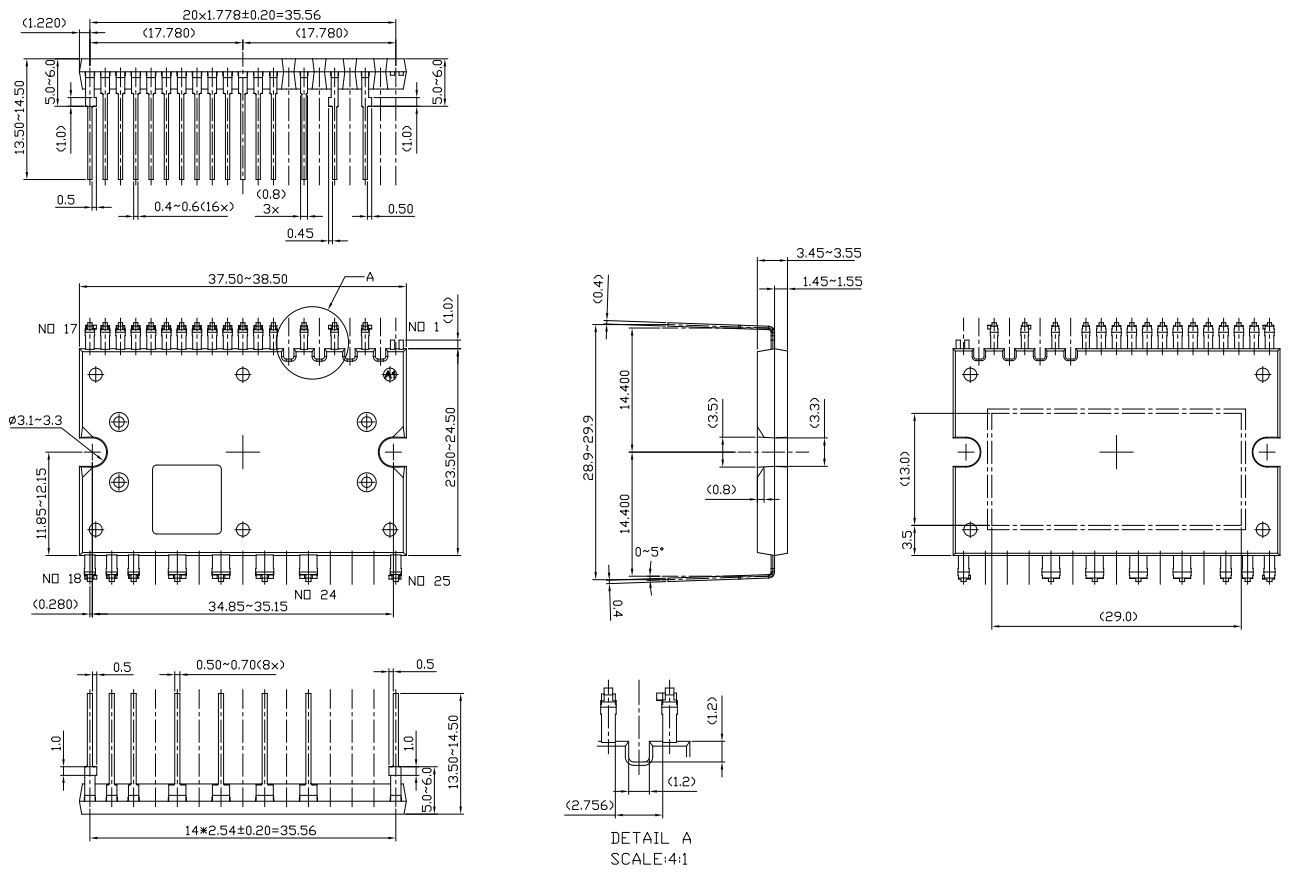
(6) Each external capacitor must be connected to the pins of IPM as close as possible;

(7) V_{FO} output is open-collector type, it should be pulled up to a 5V supply with a resistor that make Ifo up to 1mA

(8) In short circuit protection circuit, please select the time constant of RF and CSC between 1.5~2 μs, at the same time, the routing around the RF and CSC should be as short as possible. The wiring of Rf should be near the terminal of shunt resistor.

PACKAGE OUTLINE

DIP-24HL **UNIT: mm**



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Rev.: 1.1

Revision History:

1. Modify DIP-24H to DIP-24HL
2. The recommended working conditions for high side control voltage change from 16.5V to 18.5V

Rev.: 1.0

Revision History:

1. First release