Six-input Type Single Chip Inverter IC

Application Note

【Rev. 0】

Types

200V AC system	**ECN30624** **ECN30625**

Hitachi Power Semiconductor Device, Ltd.
Design Development Division

— Contents —

1. Outline

1.1 System Configuration

1.1.1 Single Chip Inverter ICs

Hitachi single chip inverter ICs are monolithic ICs integrating various constituent devices and circuits required for inverter control on a single chip. They are for driving motors, suited for variable speed control of three-phase induction motors and brushless DC motors. The advantage of downsizing by the use of a single chip structure can be used to reduce the control board in size, which can be incorporated in a motor.

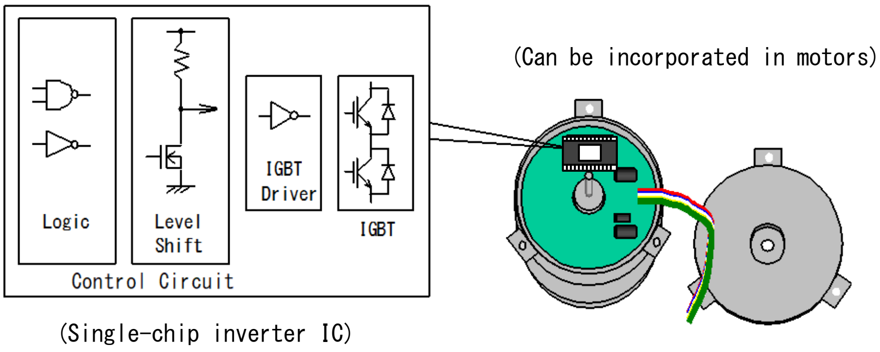


FIGURE 1.1.1.1 Image of Motor with Built-in Control Board

(a) DIP26N **(b) HSOP37N**

FIGURE 1.1.1.2 Types and Packages of IC

1.1.2 Composition of Inverter IC

An inverter is a device that converts DC currents into AC. It can be used to drive motors for efficient variable-speed control. Figure 1.1.2.1 shows the basic configuration of an inverter IC. To drive the three-phase motor with an inverter, six IGBTs and free wheel diodes are used as output stages. The IC consists of an IGBT driving power circuit, level shift circuit, a logic circuit and other components. Hitachi Inverter ICs can directly receive high voltage supplied from rectifying commercial AC power, because they have high dielectric strength. This obviates the need of a step-down circuit, thus inhibiting efficiency cuts induced by voltage conversion.

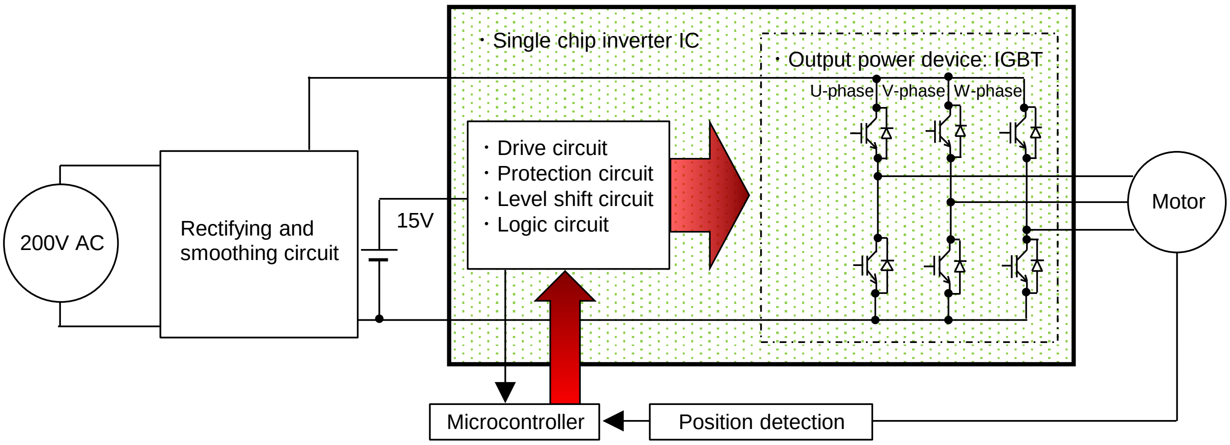


FIGURE 1.1.2.1 Example of Basic Configuration of an Inverter IC

1.2 Block Diagram of Inverter IC

Figure 1.2.1 shows a block diagram of the inverter IC.

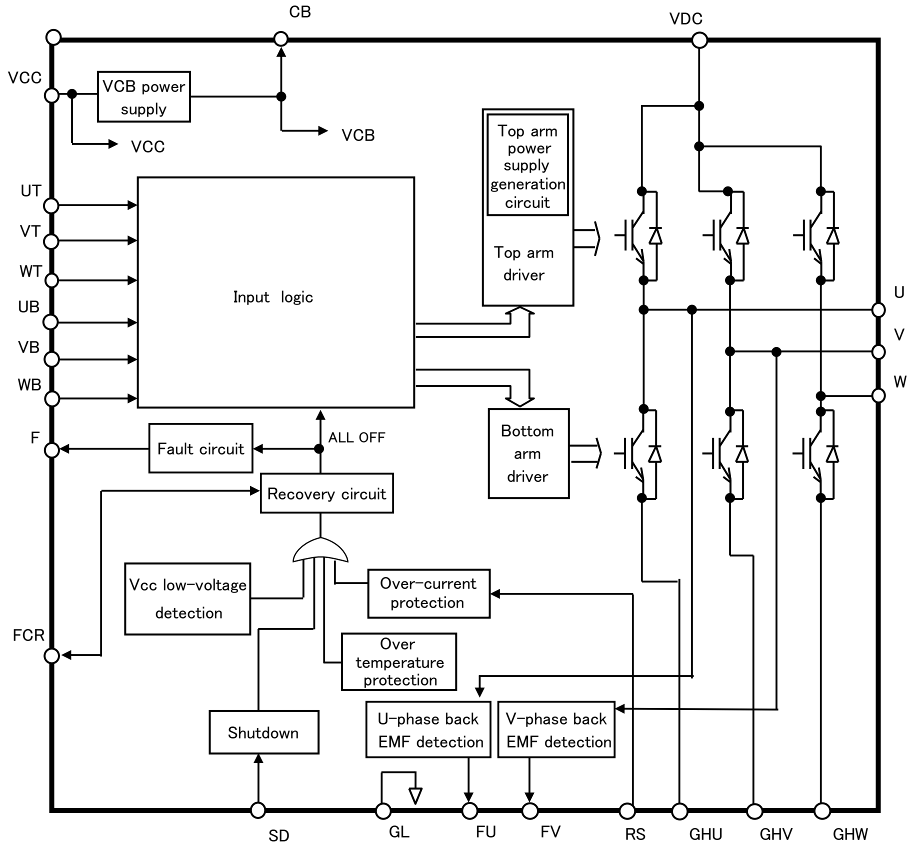


FIGURE 1.2.1 Block Diagram of Inverter IC

2. Content of Specifications

The following items have been described in the specifications.

(1) Maximum ratings

- It describes direct conditions (electric, thermal use conditions) leading to IC destruction, and so on. And the safety operating range with operating conditions is shown by minimum or maximum value.
- In a case the specified values shown in each item are exceeded, products may be damaged or destroyed even for a moment. These specified values should never be exceeded under any operating conditions.

(2) Electrical characteristics

- It provides for electric characteristics of the IC, and describes minimum, standard, and maximum.

(3) Function and operation

- It describes Truth Table, Timing Chart, Protection Function, and so on.

(4) Standard application

- It describes circuit examples and external components to operate IC.

(5) SOA and deratings

- It describes Safe Operation Area (SOA), deratings, and so on.

(6) Pin assignments and pin definitions

- It describes pin assignments, pin names and pin definitions.

(7) Inspection

- It describes inspection conditions.

(8) Important notice, precautions

- It describes notes of the static electricity, the maximum rating, handling, and so on.

(9) Appendix and reference data

- It describes packaging and dimensions.

3. Specifications

3.1 IC Types

Table 3.1.1 shows ratings, package types, and mounting types of the ICs.

TABLE 3.1.1 IC and Package Types

No.	Type	Maximum ratings	Package type	Mounting type
1	ECN30624PN	Output device withstand voltage：600V Output current (Pulse)：3A Output current (DC)：2A	DIP26N	Pin insertion type
2	ECN30625S	Output device withstand voltage：600V Output current (Pulse)：2A Output current (DC)：1A	HSOP37N	Surface mount type

3.2 Pin Locations

Table 3.2.1 shows pin locations of ECN30624PN.

TABLE 3.2.1 Pin Locations (ECN30624PN)

Pin No.	Symbol	Pin functions	Remarks
1, 3, 20, 24	NC	No connection	Note 2
2	SD	For shutdown function	
4	VDC	High voltage power supply	Note 1
5	W	W-phase output	Note 1
6	V	V-phase output	Note 1
7	U	U-phase output	Note 1
8	GHW	Emitter of W-phase bottom arm IGBT and anode of W-phase bottom arm FWD	
9	GHV	Emitter of V-phase bottom arm IGBT and anode of V-phase bottom arm FWD	
10	GHU	Emitter of U-phase bottom arm IGBT and anode of U-phase bottom arm FWD	
11	RS	Input for over-current protection	
12	UB	Input control signal for U-phase bottom arm	
13	VB	Input control signal for V-phase bottom arm	
14	WB	Input control signal for W-phase bottom arm	
15	UT	Input control signal for U-phase top arm	
16	VT	Input control signal for V-phase top arm	
17	WT	Input control signal for W-phase top arm	
18	FU	U-phase back EMF signal output	
19	FV	V-phase back EMF signal output	
21	F	Fault signal output	
22	CB	VCB power supply output	
23	FCR	For adjusting protection recovery time	
25	VCC	15V power supply	
26	GL	Ground	

Note 1. High voltage pin.

Note 2. Not connected to the chip in the IC.

Note 3. The tab potential is the same as that of the GL pin. Set the tab potential to open or the same as that of GND. If the tab is mounted on the external cabinet of the motor for heat radiation purposes, the IC will not be able to withstand an insulation withstand voltage test in which a high voltage is applied between the external cabinet and the GND. Please insert an insulation sheet or something similar between the IC tab and the external cabinet.

Table 3.2.2 shows pin locations of ECN30625S.

TABLE 3.2.2 Pin Locations (ECN30625S)

Pin No.	Symbol	Pin functions	Remarks
2, 4, 5, 6, 7, 11, 20, 27, 29, 31, 34, 36	NC	No connection	Note 1
1, 22, 23, 37	GL	Ground	
3	VCC	15V power supply	
8	FCR	For adjusting protection recovery time	
9	CB	VCB power supply output	
10	F	Fault signal output	
12	FV	V-phase back EMF signal output	
13	FU	U-phase back EMF signal output	
14	WT	Input control signal for W-phase top arm	
15	VT	Input control signal for V-phase top arm	
16	UT	Input control signal for U-phase top arm	
17	WB	Input control signal for W-phase bottom arm	
18	VB	Input control signal for V-phase bottom arm	
19	UB	Input control signal for U-phase bottom arm	
21	RS	Input for over-current protection	
24	GHU	Emitter of U-phase bottom arm IGBT and anode of U-phase bottom arm FWD	
25	GHV	Emitter of V-phase bottom arm IGBT and anode of V-phase bottom arm FWD	
26	GHW	Emitter of W-phase bottom arm IGBT and anode of W-phase bottom arm FWD	
28	U	U-phase output	Note 2
30	V	V-phase output	Note 2
32	W	W-phase output	Note 2
33	VDC	High voltage power supply	Note 2
35	SD	For shutdown function	

Note 1. Not connected to the chip in the IC.

Note 2. High voltage pin.

3.3 Functions of Pins

TABLE 3.3.1 List of Pins and Functions (1/4)

No.	Pin	Items	Functions and Precautions	Related items	Remarks
1	VCC	Control power supply pin	・Powers the drive circuits for the top and bottom arms, the built-in VCB supply circuit, and others. ・Determine the capacity of the power supply for Vcc allowing for a margin determined by adding the standby current ICC and the current taken out of the CB pin.	・3.5.1 (1) Vcc low-voltage detection ・5.1 to 5.5 Inverter IC destruction by surge or noise.	—
2	VDC	IGBT power pin	・Connected to the collectors of the top arm IGBTs.	・5.1 to 5.3, 5.6 Inverter IC destruction by surge or noise.	High voltage pin
3	CB	VCB power supply output	・Outputs a voltage (typ. 5.0V) generated in the built-in VCB power supply. ・VCB supply powers the IC internal circuits (input buffer, over-current protection and others) and can be used as a power supply for external circuits such as MCU, Hall elements, and so on. ・Connect an oscillation prevention capacitor C0 (1.0μF ±10% recommended) to the CB pin.	・3.5.4 VCB power supply	—
4	GL	Control GND pin	・It is the ground pin for Vcc and VCB power lines.	—	—
5	GHU GHV GHW	IGBT emitter pin	・The GHU, GHV and GHW pins are connected to the emitters of the U-phase, V-phase and W-phase bottom arm IGBTs respectively. ・The current in each phase can be detected by connecting a shunt resistor Rs between these pins (GHU, GHV, GHW) and the GL pin. ・DC current can be detected by connecting the GHU, GHV and GHW pins all together and connecting a shunt resistor Rs between the RS pin and the GL pin.	・3.5.1 (2) Setting method for over-current protection	—
6	U V W	Inverter output pin	・These are outputs of a three-phase bridge consisting of six IGBTs and free wheel diodes.	—	High voltage pin

TABLE 3.3.1 List of Pins and Functions (2/4)

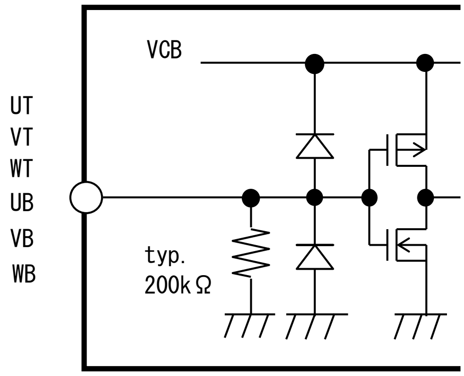
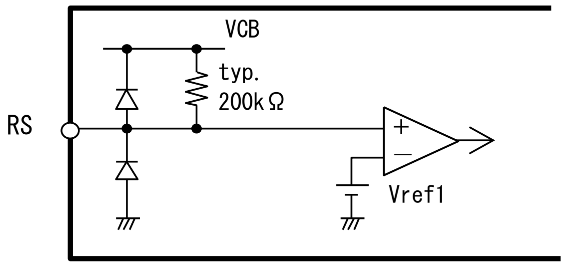
No.	Pin	Items	Functions and Precautions	Related items	Remarks
7	UT VT WT UB VB WB	Control signal input pin for each arm	・Inputs control signals of each phase. ・When inputting "H", the IGBTs turn on. When inputting "L", the IGBTs turn off. ・U, V and W stand for each phase. T and B stand for top arm and bottom arm respectively. ・If the switching noise is monitored, mount a capacitor. ・The maximum rating of input voltage is VCB+0.5V.	—	—
		 **FIGURE 3.3.1 Equivalent Circuit Around UT, VT, WT, UB, VB, WB Pins**			
8	RS	For over-current protection	・Monitors the voltage of the shunt resistor Rs and detects over current status.	・3.5.1 (2) Setting method for over-current protection	—
		 **FIGURE 3.3.2 Equivalent Circuit Around RS Pin**			

TABLE 3.3.1 List of Pins and Functions (3/4)

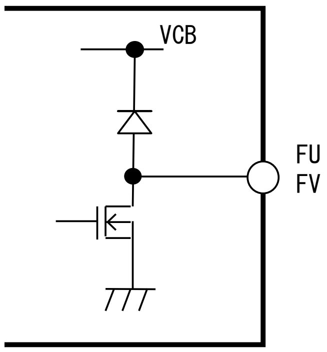
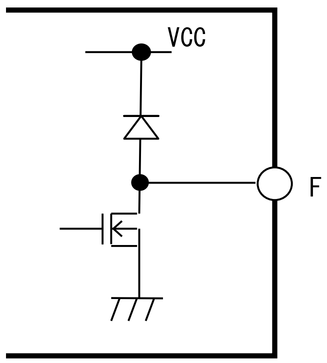
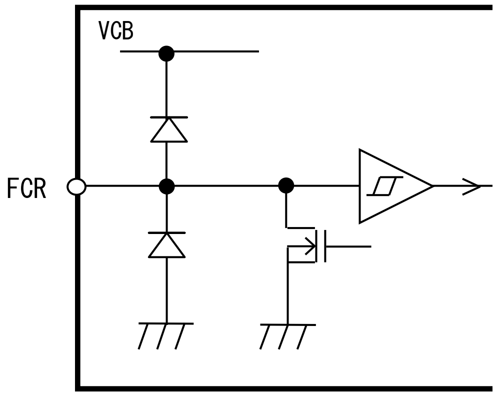
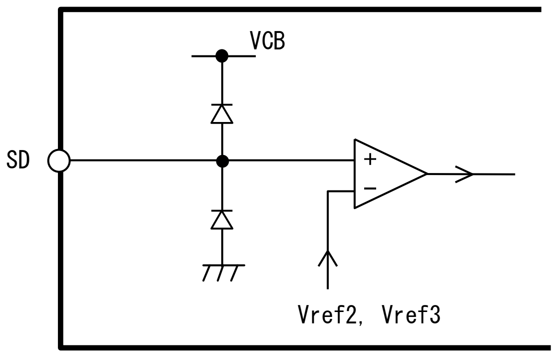
<table>
<tr><th>No.</th><th>Pin</th><th>Items</th><th>Functions and Precautions</th><th>Related items</th><th>Remarks</th></tr>
<tr><td rowspan="2">9</td><td rowspan="2">FU
FV</td><td>Output pin for back EMF signal</td><td>・NMOS open drain output pin. Pull up to CB or 5V through the external resistor RF* (10kΩ±5% recommended).
・Outputs back EMF information of each phase when input signals to the control input pins of each arm are all “L” (UT, VT, WT, UB, VB, WB = L).
・Outputs “H” independently when each voltage at the U and V pins is VIHE or more. Outputs “L” independently when each voltage at the U and V pins is VILE or less.</td><td>・3.5.5
Back EMF detection circuit</td><td rowspan="2">—</td></tr>
<tr><td colspan="3">
FIGURE 3.3.3 Equivalent Circuit Around FU, FV Pins</td></tr>
<tr><td rowspan="2">10</td><td rowspan="2">F</td><td>Fault signal output</td><td>・NMOS open drain output pin
・The NMOS turns on only when the over-current protection operates, and in other cases, the NMOS is off.
・Pull up to the CB pin or 5V through an external resistor RF. Moreover, to remove switching noise, connect the capacitor CF (0.01μF±10% recommended) between the F pin and GND.</td><td>・3.5.1
Protection function</td><td rowspan="2">—</td></tr>
<tr><td colspan="3">
FIGURE 3.3.4 Equivalent Circuit Around F Pin</td></tr>
</table>

TABLE 3.3.1 List of Pins and Functions (4/4)

No.	Pin	Items	Functions and Precautions	Related items	Remarks
11	FCR	For adjusting protection recovery time	・NMOS open drain pin. ・Outputs “L” when any of the protection functions (over-current, over temperature, or shutdown) operates. ・After that, when the protection recovery conditions are satisfied and protection recovery time (Trs or Trs2) determined by RFCR and CFCR passes, the FCR pin and F pin outputs are “H”, and the IC returns to a state in which the IGBTs operate depending on input signals. ・”L” is not outputted when the Vcc low-voltage detection operates. After the protection recovery conditions are satisfied and the protection recovery time (Trs2) passes, the F output is “H” and the IC returns to a state in which the IGBTs operate depending on input signals.	・3.5.1 (5) Protection recovery time adjusting function	–
		 **FIGURE 3.3.5 Equivalent Circuit Around FCR Pin**			
12	SD	For shutdown function	・When this function is used as an over-voltage protection on the VDC pin, connect the external resistors ROVP1, ROVP2 and a capacitor COVP. When not used, connect this pin to the GL pin.	・3.5.1 (4) Shutdown function	–
		 **FIGURE 3.3.6 Equivalent Circuit Around SD Pin**			

3.4 Markings

The resin surface of the IC is marked.

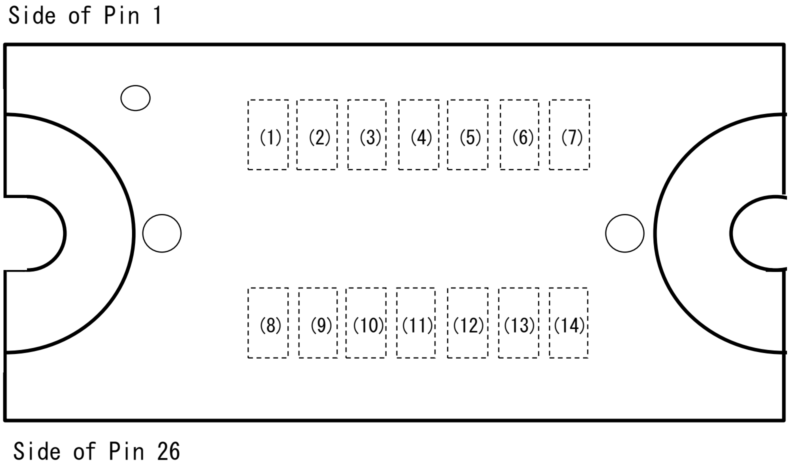


FIGURE 3.4.1 DIP26N Marking Specifications

Mark No. (1) to (7): Type name
Mark No. (8) to (14): Lot number

The lot number consists of the followings.

No. (8)(9): Quality control number
Represented with letters from “A” to “Z” except “I” and ”O”, numbers from “0” to “9”, or blank.

No. (10): Last one-digit of the year of assembly

No. (11): Month of assembly:
January: A, February: B, March: C April: D, May: E, June: K,
July: L, August: M, September: N, October: X, November: Y, December: Z

No. (12) to (14): Quality control number
Represented with letters from “A” to “Z” except “I” and ”O”, numbers from “0” to “9”, or blank.

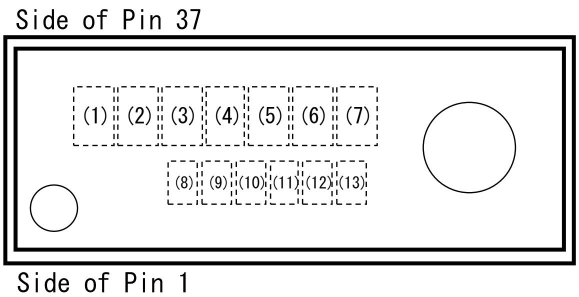


FIGURE 3.4.2 HSOP37N Marking Specifications

Mark No. (1) to (7): Type name
Mark No. (8) to (13): Lot number

The lot number consists of the followings.

No.(8) (9): Last two digits of the year of assembly

No.(10): Month of assembly:
January: A, February: B, March: C April: D, May: E, June: K,
July: L, August: M, September: N, October: X, November: Y, December: Z

No.(11) to (13): Quality control number
Represented with letters from “A” to “Z” except “I” and ”O”, numbers from “0” to “9”, or blank.

3.5 Functions and Operational Precautions

3.5.1 Protection Function

(1) Vcc low-voltage detection

Hitachi Power Semiconductor Device calls the Vcc low-voltage detection “LVSD”. When the Vcc voltage drops below the LVSD operating voltage (LVSDON, typ.12.0V), the F output is “L”, and all IGBTs (top and bottom arms) are turned off. When the Vcc voltage goes up to a level equal to or exceeding the LVSD recovery voltage (LVSDOFF, typ. 12.5V) and the protection recovery time (Trs2, min. 20μs) passes, the F output is “H”, and the IC automatically returns to a state in which the IGBTs operate depending on input signals. The protection recovery time is fixed at Trs2.

If the Vcc low-voltage detection operates during motor rotation, Vdc voltage may rise due to regenerative electric power to the Vdc power supply. The voltage at the VDC pin must not exceed the maximum rating. Particular attention is needed when the capacitance of a capacitor between the VDC and GND is small, because it makes the voltage more likely to rise.

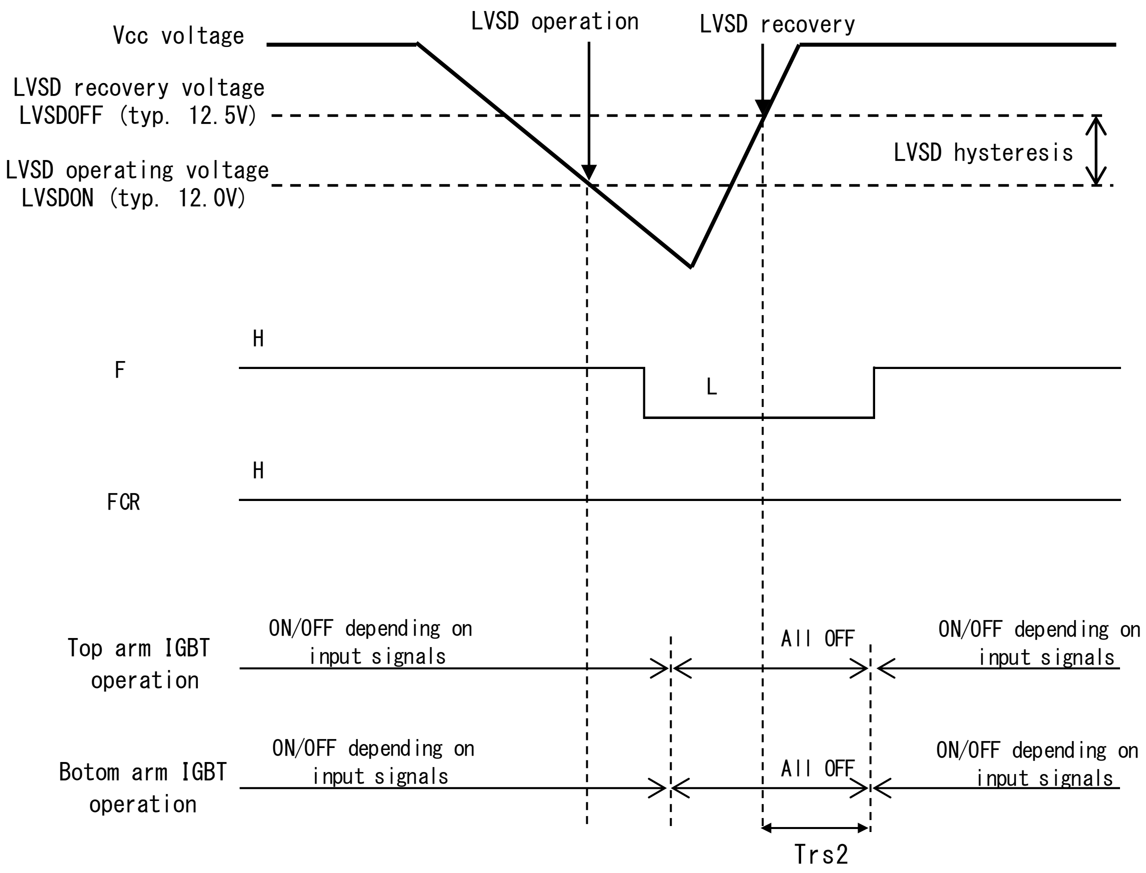


FIGURE 3.5.1.1 Timing Chart for Vcc Low-voltage Detection Operation

(2) Setting method for over-current protection

Figure 3.5.1.2 shows an example of the current flowing through the shunt resistor Rs when this function is enabled. This function is not effective for currents that do not flow forward (direction to the GL pin) through the shunt resistor, such as reflux current and power regenerative current (see Figs. 3.5.1.3 and 3.5.1.4).

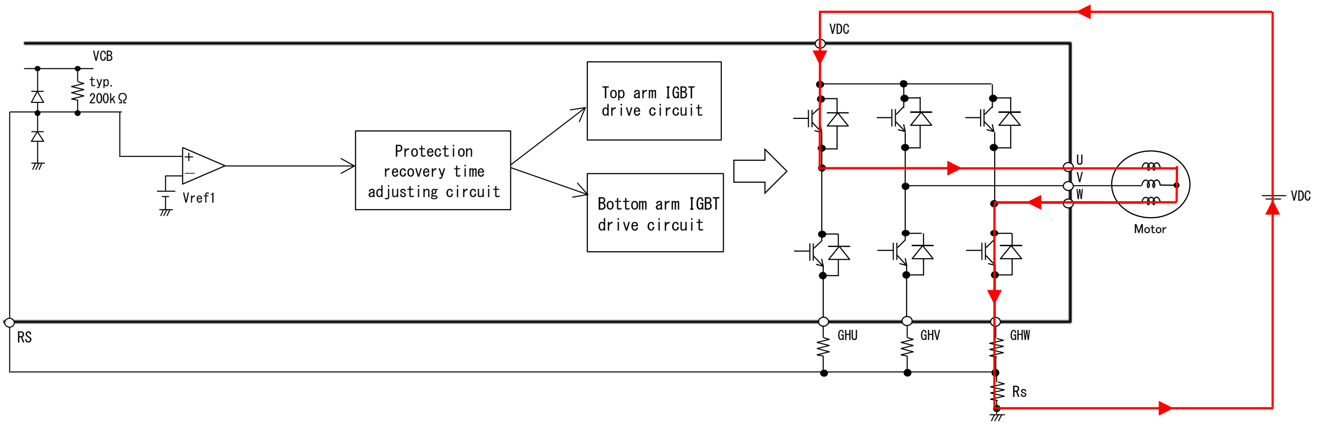


FIGURE 3.5.1.2 Example of Current Path of Enabled Over-current Protection

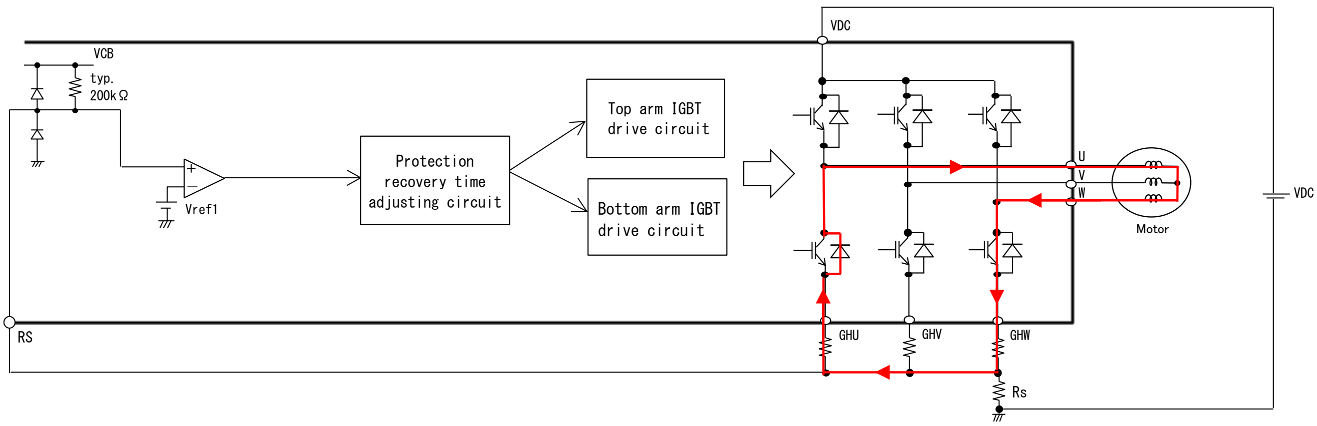


FIGURE 3.5.1.3 Example of Reflux Current

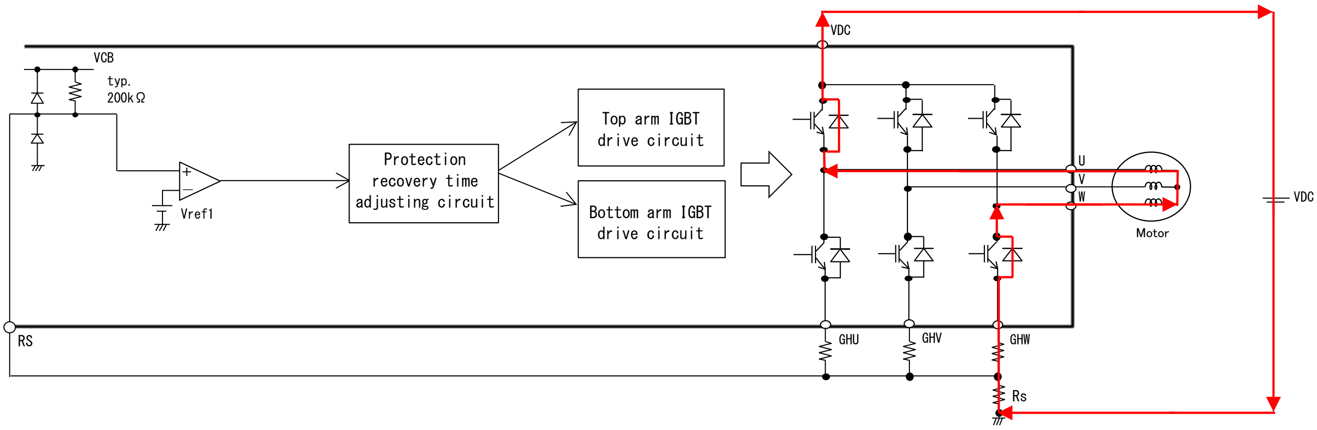


FIGURE 3.5.1.4 Example of Power Regenerative Current

(a) Over-current protection

When the voltage at the RS pin reaches the over-current protection reference voltage (Vref1, typ. 0.80V), the F output is “L”, and all IGBTs (top and bottom arms) are turned off. When the voltage at the RS pin drops below the over-current protection reference voltage (Vref1, typ. 0.80V) and the over-current protection recovery time passes, the F output is “H”, and the IC automatically returns to a state in which the IGBTs operate depending on input signals. The protection recovery time is adjustable using FCR pin, and the adjustment method is shown in Section 3.5.1 (5).

Figure 3.5.1.5 shows the timing chart for the over-current protection operation.

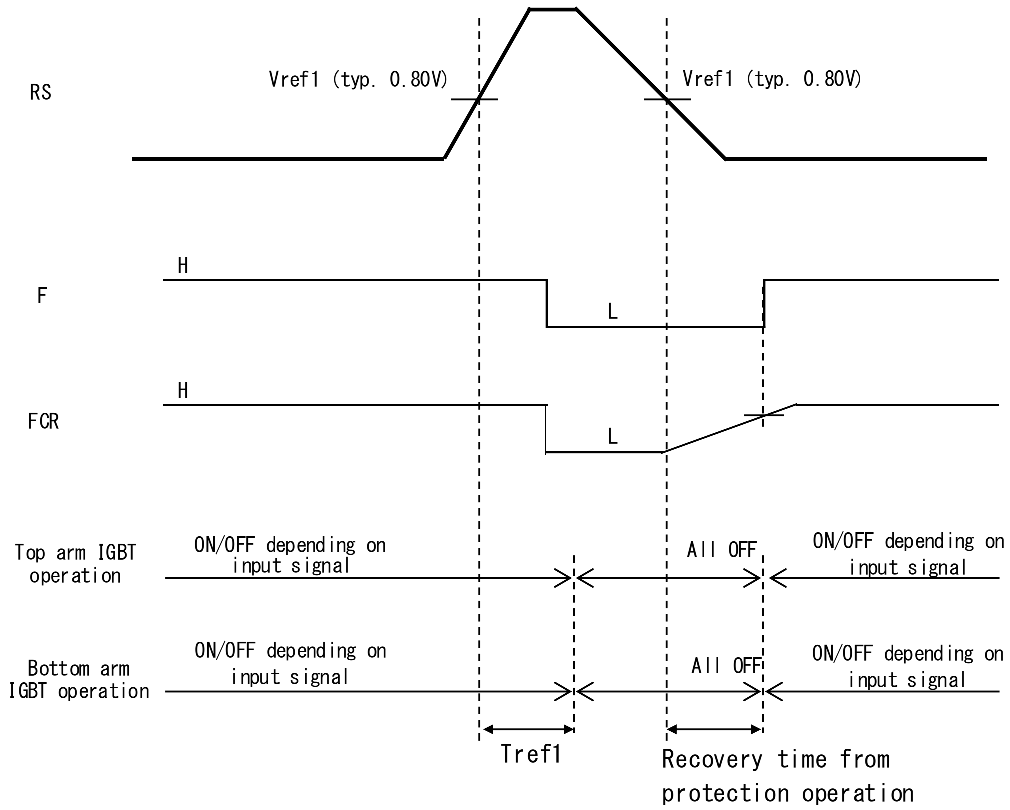


FIGURE 3.5.1.5 Timing Chart for Over-current Protection Operation

(b) How to set current value of over-current protection

The current value of over-current protection operation IO is calculated as follows:

IO=Vref1/Rs

Where

Vref1: Over-current protection reference voltage
Rs : Shunt resistance value

In setting current values, delay time to turn the IGBT off (Tref1), Vref1 variability and Rs variability need to be considered. Observe the output currents of the IC (the coil currents of the motor) and confirm a design margin. Set the shunt resistance so that voltages of the GHU, GHV, and GHW pins are within the specified GH voltage (Vgh) range in the Product Specification.

(c) Wiring precautions

Make the wiring of the shunt resistor Rs as short as possible. The GHU, GHV and GHW are connected to the IGBT emitters. If the wiring has high resistance or high inductance component the emitter potential of the IGBT changes, which can result in IGBT malfunction.

(3) Over temperature protection

When the IC temperature exceeds the operating temperature of over temperature protection (TSDON, typ. 160˚C), the F output is "L", and all IGBTs (top and bottom arms) are turned off. When the IC temperature goes down the hysteresis (TSDHYS, typ. 25˚C) from the operating temperature of over temperature protection (TSDON, typ. 160˚C) and protection recovery time passes, the F output is "H", and the IC automatically returns to a state in which the IGBTs operate depending on input signals. The protection recovery time is adjustable using FCR pin, and the adjustment method is shown in Section 3.5.1 (5).

Figure 3.5.1.6 shows the timing chart for the over temperature protection operation.

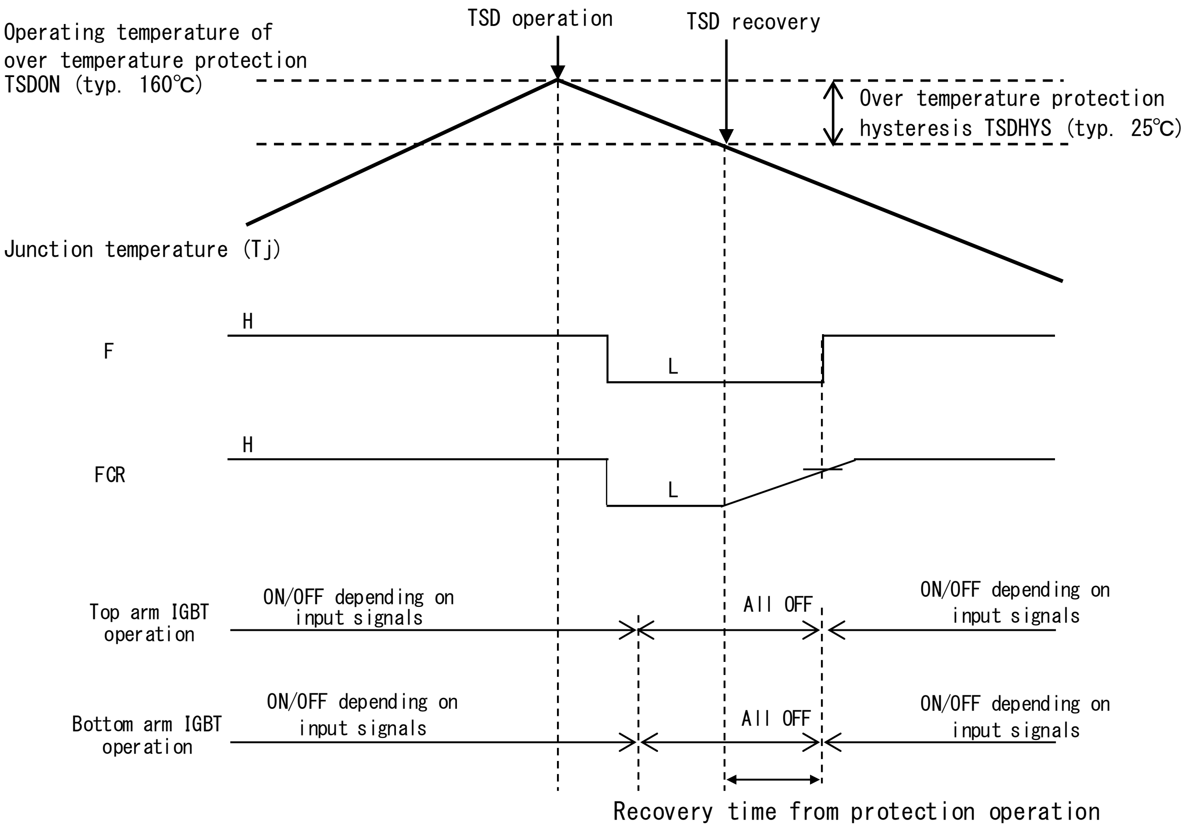


FIGURE 3.5.1.6 Timing Chart for Over Temperature Protection Operation

(4) Shutdown function

When the voltage at the SD pin reaches the shutdown operating voltage (Vref2, typ. 1.23V), the F output is "L", and all IGBTs (top and bottom arms) are turned off. After that, when the voltage at the SD pin falls below the shutdown recovery voltage (Vref3, typ. 1.18V) and protection recovery time passes, the F output is "H", and the IC automatically returns to a state in which the IGBTs operate depending on input signals. The protection recovery time is adjustable using the FCR pin, and the adjustment method is shown in Section 3.5.1 (5).

This function can be used as an over-voltage protection when over-voltage is applied on the VDC pin. The operating voltage and recovery voltage of the over-voltage protection are adjustable by the resistance values of external resistors ROVP1 and ROVP2 which are connected between the VDC pin and GL pin. These voltages can be calculated using the following equations:

$$\text{Over-voltage protection operating voltage: } OVPON(V) = \frac{ROVP1(\Omega) + ROVP2(\Omega)}{ROVP2(\Omega)} \times Vref2(V)$$

$$\text{Over-voltage protection recovery voltage: } OVPOFF(V) = \frac{ROVP1(\Omega) + ROVP2(\Omega)}{ROVP2(\Omega)} \times Vref3(V)$$

When this function is not used, connect the SD pin to the GL pin. Figure 3.5.1.7 shows the timing chart for shutdown function operation.

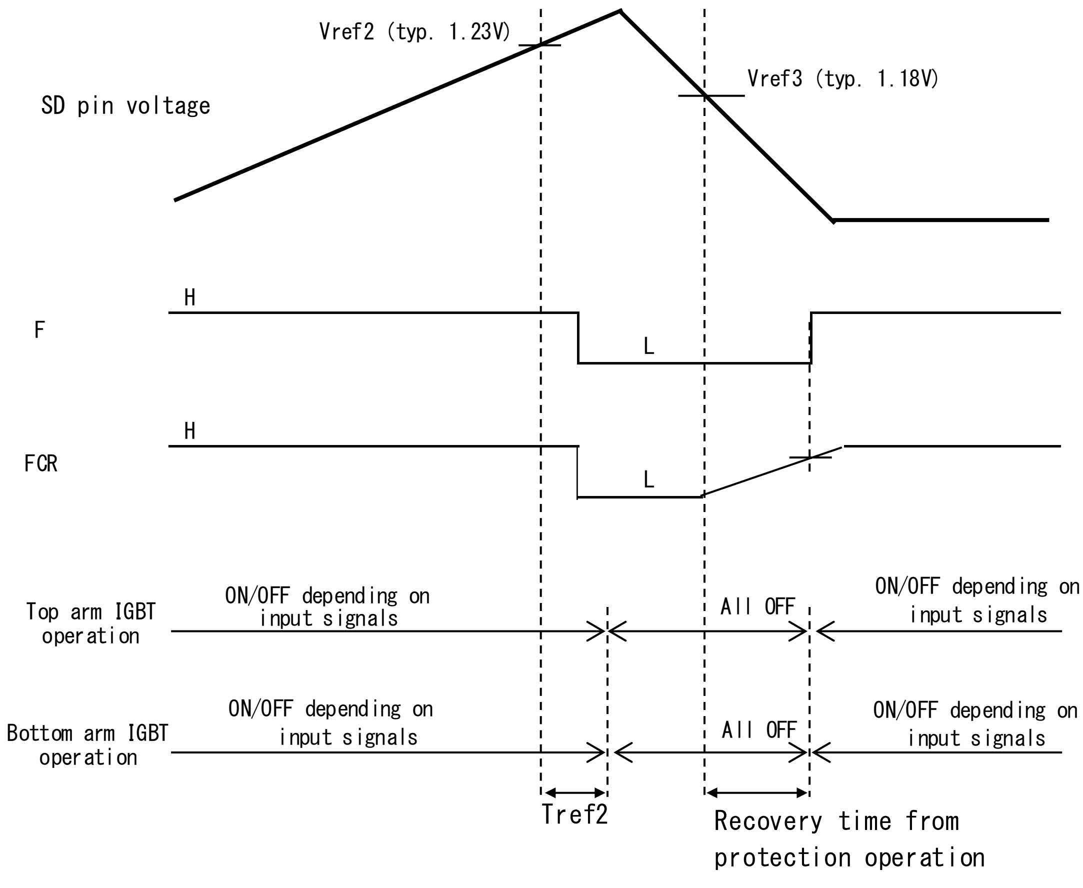


FIGURE 3.5.1.7 Timing Chart for Shutdown Function Operation

(5) Protection recovery time adjusting function

The FCR pin is used for adjusting the protection recovery time. Connect the RFCR and CFCR between the CB pin and GL pin. Then, connect the midpoint of the CB pin and GL pin to the FCR pin. See the connection example in Figure 4.1.1. When any of the protection functions (over-current, over temperature, or shutdown function) operates, the voltage at the FCR pin is “L”. After that, when the protection recovery conditions are satisfied and protection recovery time (Trs) determined by RFCR and CFCR passes, the F output is “H”, and the IC returns to a state in which the IGBTs operate depending on input signals. On the other hand, when RFCR=10kΩ is connected between the CB pin and FCR pin with the CFCR unconnected, after the protection recovery conditions are satisfied and protection recovery time (Trs2) determined by the internal circuit passes, the F output is “H”, and the IC returns to a state in which the IGBTs operate depending on input signals. When the Vcc low-voltage detection operates, the protection recovery time is Trs2 regardless of RFCR and CFCR values.

Trs can be calculated as follows.

$$Trs(ms) = Trs1\ (ms)_{*} \times \frac{RFCR(M\Omega)\ \times CFCR(pF)}{1(M\Omega)\ \times 1000(pF)}$$

* Trs1 (typ. 1ms)

Please set RFCR to 500kΩ to 2MΩ and CFCR to 1000pF to 5000pF as a guide.
Table 3.5.1 shows the relationship between each protection function and protection recovery time.
Figure 3.5.1.8 shows the timing chart in case of FCR pin connected to RFCR and CFCR. Figure 3.5.1.9 shows the timing chart in case of RFCR=10kΩ connected to FCR pin with CFCR unconnected.

TABLE 3.5.1 Relationship Between Protection and Protection Recovery Time

Protection function	Protection recovery time	
	When protection recovery time adjusting function is enabled (When RFCR, CFCR are connected to FCR pin)	When protection recovery time adjusting function is disabled (When RFCR=10kΩ is connected to FCR pin with CFCR unconnected)
Vcc low-voltage detection	Trs2	Trs2
Over-current protection	Trs	
Over temperature protection		
Shutdown function		

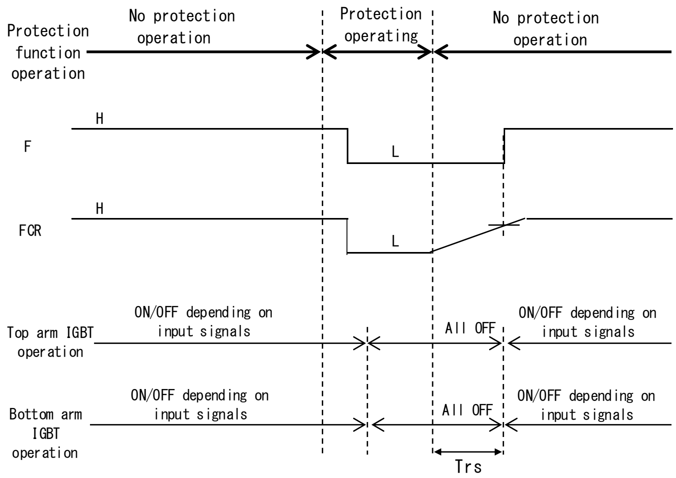


FIGURE 3.5.1.8
Timing Chart in Case of Protection Recovery Time Adjusting Function Enabled (Except for Vcc low-voltage detection)

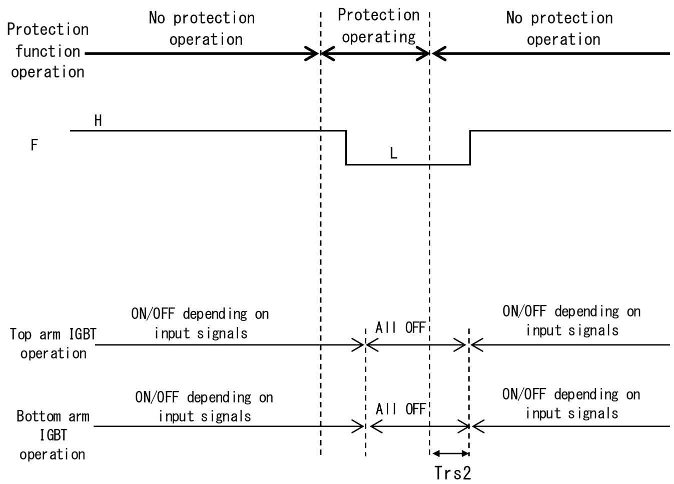


FIGURE 3.5.1.9
Timing Chart in Case of Protection Recovery Time Adjusting Function Disabled

(6) Short-circuit protection

If output of the inverter is short-circuited (load short-circuit, earth fault, and short-circuit between the top and bottom arms), there is a possibility that the IC will be destroyed. The over-current protection prevents damage to the IC due to load short-circuit and short-circuit between the top and bottom arms. However, in the case of earth fault whose current does not flow through the shunt resistor, the over-current protection does not operate because the IC cannot detect over-current. Thus, be sure to protect the device using external circuits of the IC in order to prevent damage caused when the IC cannot detect over-current such as an earth fault. Two or more occurrences of short-circuits can lead to the IC damage or failure because of local heat generated in the IGBTs. Proper precautions should be taken to prevent the over-current protection from operating repeatedly more than once caused by short-circuit.

3.5.2 New Bootstrap

The new bootstrap is a power supply method for the top arm that is characterized by charging the built-in capacitor in the IC from the Vdc power supply (high voltage power supply). A low PWM frequency lowers the charge voltage in the built-in capacitor, which could cause a higher voltage drop of the top arm output. As a guide, the PWM frequency should be 20 kHz (14 kHz ≤ fPWM ≤ 30 kHz is recommended).

If the output ON-duty is high, a voltage drop of the top arm output may increase because the charging time of the built-in capacitor is insufficient. The output ON-duty ratio should be 98% or less.

When the Vdc power supply voltage is low, the built-in capacitor is not sufficiently charged. That could cause a higher voltage drop of the top arm output. The Vdc power supply voltage should be within the voltage range specified in the Product Specification.

3.5.3 Power On/Off Sequence

Sequence free in followings (1), (2), and (3).

(1) Power-on sequence
(2) Power-off sequence
(3) Power-off and reset operation in instantaneous power failure occurrence

3.5.4 VCB Power Supply

The VCB power supply is generated from Vcc power supply and outputted from the CB pin. The VCB power is supplied to the IC internal circuits such as the over-current protection circuit. Figure 3.5.4.1 shows an equivalent circuit. This circuit constitutes a feedback circuit.

To prevent oscillation, connect capacitor C0 to the CB pin. The recommended capacitance for the C0 is 1.0μF±10%. The larger the C0 capacity, the more stable the VCB power supply. However, excessive capacitance is not recommended. As a guide, it should be 2μF to 3μF or less.

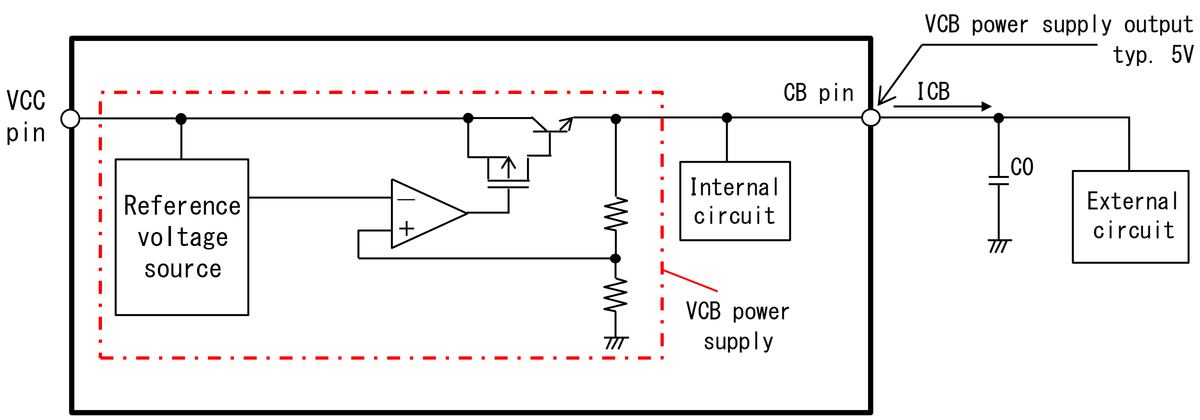


FIGURE 3.5.4.1 Equivalent Circuit for VCB Power Supply

3.5.5 Back EMF Detection Circuit

When an external force makes the motor rotate (free-running) while the inverter stops operating, the back EMF signals are outputted as information on the rotor position. The U-phase back EMF signal and V-phase back EMF signal are outputted from the FU and FV pins respectively. Figure 3.5.5.1 shows a timing chart. A condition to output the back EMF signals is satisfied when the UT, VT, WT, UB, VB and WB pin inputs are all “L”. In the other conditions, you must not use the signals from the FU and FV pins as the information on the rotor position. When motor speed is decreased and the back EMF goes down below the detection level (VILE), the FU and FV pin outputs are “L”. In using this signal, consider motor variance and detection level variance.

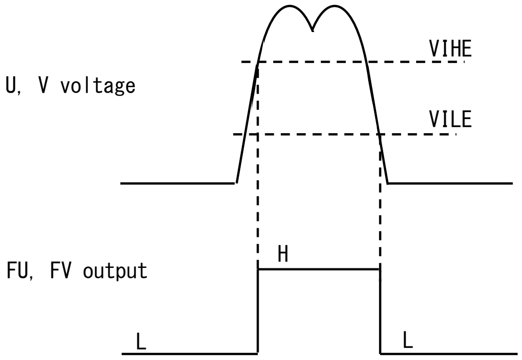


FIGURE 3.5.5.1 Timing Chart for Motor Output (U, V) and FU, FV Pin Signal Output

3.5.6 Internal Filter Circuit

Internal filter circuits are located before the top and bottom arm drivers. The filter circuits remove signals and switching noise with widths less than about 0.5μs inputted to the input pins (UT, VT, WT, UB, VB, WB).

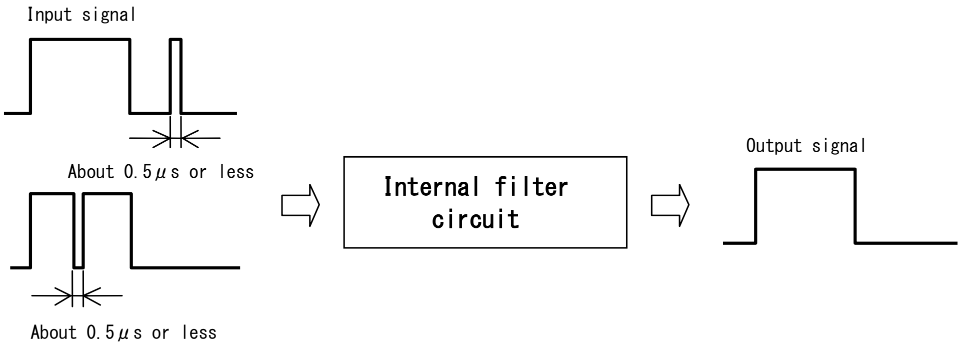


FIGURE 3.5.6.1 Operation of Internal Filter Circuit

3.5.7 Derating

How much to derate a unit from the maximum rating is an important issue to consider for a reliable design. Items to be considered in the stage of system design include the derating of voltage, current, power, load, and electric stresses, along with the derating of temperature, humidity, other environmental conditions, vibration, impact, and other mechanical stresses.

Table 3.5.7.1 specifies the standard examples of derating to be considered when creating a reliable design. To consider these derating items in the equipment design stage is desirable for achieving reliability. If any item is difficult to be controlled within the standard, another means will be necessary, such as selecting a device having higher maximum ratings. Please consult our sales representative in advance.

TABLE 3.5.7.1 Typical Derating Design Standards

Item	Type	
	ECN30624PN	ECN30625S
Junction temperature Tj	110°C maximum	
Vdc power supply voltage	450V maximum	
Output peak current	1.4A maximum	0.7A maximum

3.6 Handling

3.6.1 Mounting

(1) Insulation between pins

High voltages are applied between the pin numbers specified below. Please apply coating resin or molding treatment as necessary.

・DIP26N: Between pin numbers: 2-3, 4-5, 5-6, 6-7, 7-8

・HSOP37N: Between pin numbers: 26-28, 28-30, 30-32, 32-33, 33-35

(2) Connection of tabs

The tab and the GL pin of the IC are connected in the frame. Regarding the tab, take note of the following points.

(a) DIP26N

The tab is placed on the IC upper surface. If a heat sink is attached to the tab by screwing, set the heat sink potential to the same as that of the GL pin. If a heat sink is not attached to the tab and it is required to insulate between the IC tab and the housing, please insert an insulation sheet or something similar between them. If the insulation between the tab and the housing is insufficient, the IC will not be able to withstand an isolation withstand voltage test in which a high voltage is applied between the housing and the GND.

(3) Lead pin reliability

When using DIP26N with the heat sink attached, the lead pin can be destroyed by vibration or impact depending on conditions of use because a load is applied to the lead pin. Please sufficiently assess the IC by a vibration test after mounting the IC. In particular, please note that space between the IC body (resin part) and PCB increases a load.

(4) Tab suspension

Figure 3.6.1.1 shows a side view of the IC.

There are parts called “tab suspension” on both side surfaces of the IC. These tab suspensions are connected to the same potential as the GL pin. When the high voltage wire or/and components are laid out close to the tab suspensions, insulate them with coating, mold, or other treatment.

FIGURE 3.6.1.1 Side Views of ICs

(5) Coating resin

The influence of coating resin on semiconductor devices (thermal stress, mechanical stress and other stress) depends on PCB size, mounted components, etc. to be used. When selecting a coating resin, consult with your PCB manufacturer and resin manufacturer.

(6) Soldering conditions

(a) Soldering condition for DIP26N

The peak temperature of flow soldering* must be 260°C or less, and the dip time must be within 10 seconds. High stress by mounting, such as long time thermal stress by preheating, mechanical stress, etc., can lead to degradation or destruction. Make sure that your mounting method does not cause problem as a system.

If attaching a heat sink, do not solder to the tab. The solder on the tab impairs the tab flatness, which causes poor contact with the heat sink mounting surface. As a result, the heat dissipation may decrease.
※ Flow soldering: Only pins enter a solder bath, while the resin or tab does not.

(b) Soldering conditions for HSOP37N

This IC is lead-free (Pb-free). The recommended reflow soldering condition is shown in Figure 3.6.1.2.

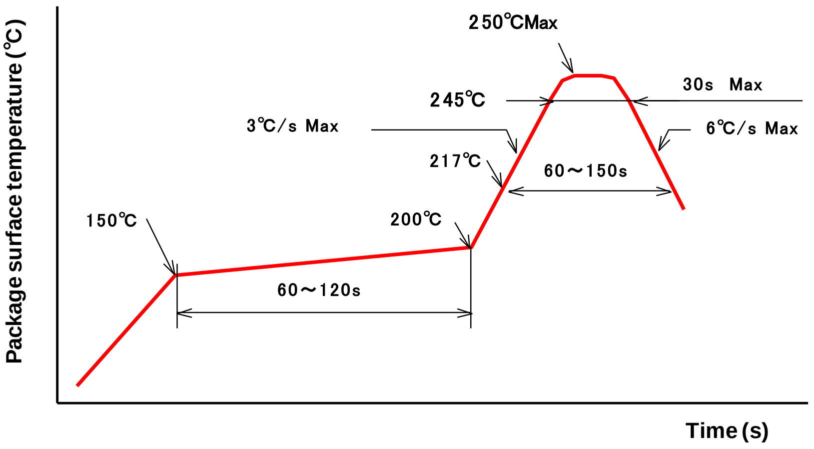


FIGURE 3.6.1.2 Recommended Conditions for Infrared Reflow or Air Reflow

(7) Solder joint reliability

Reliability of solder joints is influenced by soldering conditions, PCB material and foot patterns. Perform adequate evaluations on thermal cycle tests, heat shock tests, and other tests after mounting the IC on a PCB. Special care should be taken if the HSOP37N is mounted on a PCB having a high coefficient of thermal expansion (such as CEM-3) because the solder joint life could be shortened.

3.6.2 Precautions for Mounting Heat Sink

To radiate heat of the IC, attaching a heat sink to the tab side is effective. When attaching a heat sink, please select DIP26N. Then, it is recommended to attach a heat sink to the IC body (resin part) by screwing. If other methods are used such as attaching with a clip or attaching to PCB by screwing, problems can be caused such as variation of adhesion strength between a heat sink and the IC or deterioration in reliability of attachment points. For these reasons, please select and adopt a method at the user's own responsibility. When attaching a heat sink to DIP26N by screwing, set the heat sink potential to the same as that of the GL pin and note the following points.

(1) Heat sink

Inappropriate heat sinks will hinder heat radiation. In addition, adding unnecessary stress will cause characteristic degradation or resin cracks.

Observe the following points regarding heat sinks:

(a) To avoid a heat sink causing convex or concave warping, keep the warp and twisting between screw holes less than or equal to 0.05 mm (Fig. 3.6.2.1).

(b) For aluminum, copper, and iron boards, make sure there is no press tension, and always bevel the screw holes.

(c) A contact surface with the IC must be ground flat. (Average surface roughness **Ra** shall be 3.2 to 6.3 μm.)

(d) Prevent and remove any shaved particles between the IC tab and the heat sink.

(e) Make sure the screw hole gaps match those of the IC (typ. 29.5mm). If they are too wide or too narrow, resin cracks may occur.

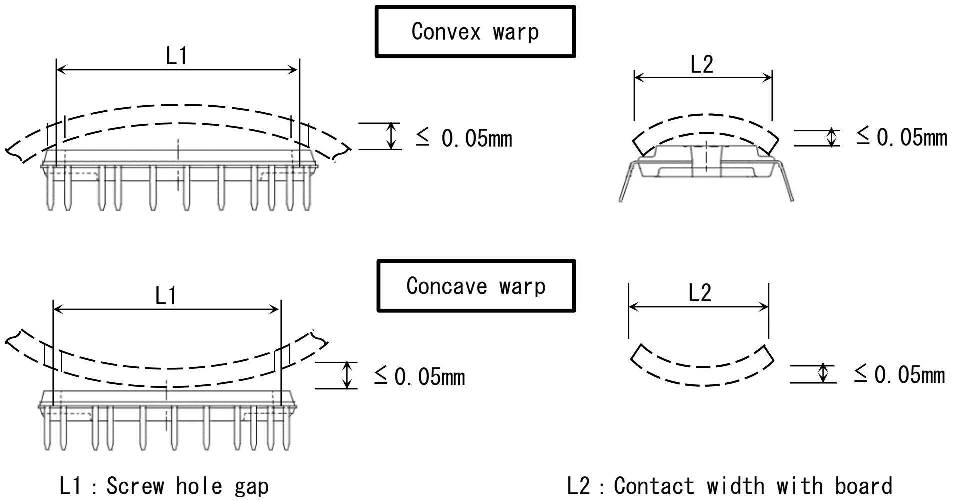


FIGURE 3.6.2.1 Heat Sink Warping

(2) Screws

The screws that attach the heat sink to the device are generally classified into small screws and tapping screws. Observe the following precautions when using these types of screws:

(a) Use small bind and truss screws that have heads which meet JIS-B1101 standards.
(b) Avoid using countersink screws, which add abnormal stress to devices (Fig. 3.6.2.2).
(c) The use of tapping screws increases tightening torque. Therefore, there is a possibility that desired contact resistance cannot be obtained. When using tapping screws, prevent tightening torque from becoming too large. For tightening torque, see Section 3.6.2 (3).
(d) When using a tapping screw, use one that is thinner than the IC attachment hole diameter. If thicker screws are used, tapping the IC attachment holes or heat sinks can promote failures.

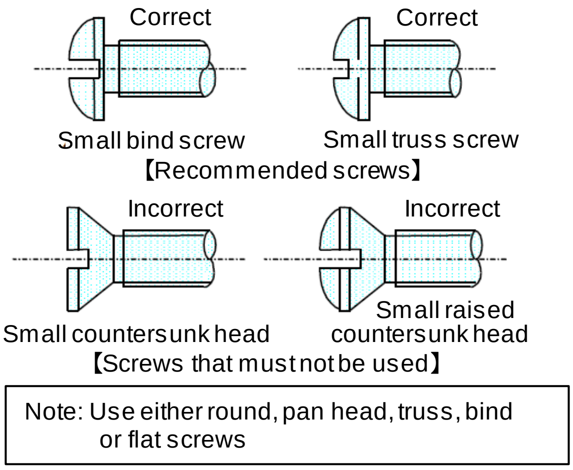


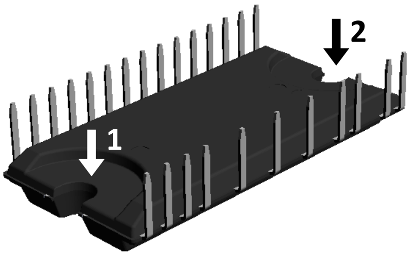
FIGURE 3.6.2.2 Recommended and Prohibited Screws

(3) Tightening method

Insufficient tightening torque invites an increase in heat resistance, and excessive torque invites such failures as warping of the device, cracking of resin, die destruction, and connector lead breakage. Please use the tightening torque value 0.39 to 0.59N･m (4 to 6 kg･cm). (Attached screw: M3)

Use a manual torque screwdriver or electric screwdriver for tightening. Do not use an impact driver. When using an electric screwdriver, the maximum rotation speed at the time of tightening must be 700 rpm. If tightened at higher speeds than 700 rpm, the IC is overstressed, which may result in resin cracking.

Tightening sequence is shown as Fig. 3.6.2.3.



(a) Tightening sequence
Temporary tightening: 1 -> 2
Final tightening: 1 -> 2

Torque for temporary tightening should be 20 - 30 % of maximum torque.

(b) Flat washer or spring washer should be put in.
IC might get crack without the washer.

FIGURE 3.6.2.3 Typical Tightening Sequence

(4) Silicone grease

Apply a thin layer (100um or less) of silicon grease evenly over the contact surface between the IC and the heat sink to maximize heat conduction. Applying more silicon grease than necessary may reduce heat dissipation and overstress the IC, which may result in resin cracking. Moreover, avoid high-viscosity (hard) greases to prevent resin from cracking.

Example of silicone grease is shown in Table 3.6.2.1. We recommend the silicone grease shown below or comparable one.

TABLE 3.6.2.1 Recommended Silicone Grease

No.	Product name	Manufacturer
1	G-747	Shin-Etsu Chemical Co., Ltd

4. Recommended Circuit

4.1 External Components

Table 4.1.1 shows recommended external components.

TABLE 4.1.1 External Components

Component	Standard value	Usage	Remarks
C0	1.0μF±10%, 25V	Smooths the internal power supply (VCB)	
CV1	1.0μF±10%, 25V	Smooths the Vcc power supply	Note 1
CV2	33nF±10%, 630V	Smooths the Vdc power supply	Note 1
Rs	1Ω±1%, 1W	Sets over-current protection	Note 2 for how to set Rs.
RFU, RFV	10kΩ±5%	For pull up	
CF	0.01μF±10%, 25V	Eliminates output noise of Fault signal	
RF	10kΩ±10%	For pull up	
CFCR	1000pF±10%, 25V	Sets protection recovery time	When the protection recovery time adjusting function is enabled, connect RFCR and CFCR to FCR pin.
RFCR	1MΩ±10%		
CFCR	–	–	When the protection recovery time adjusting function is disabled, connect RFCR to FCR pin and do not connect CFCR to FCR pin.
RFCR	10kΩ±10%	For pull up	
ROVP1	–	Sets over-voltage protection operating voltage/recovery voltage	Note 3 for how to set ROVP1.
ROVP2	–	Sets over-voltage protection operating voltage/recovery voltage	Note 3 for how to set ROVP2.
COVP	0.1μF±10%, 25V	Eliminates input noise of SD signal	Note 4

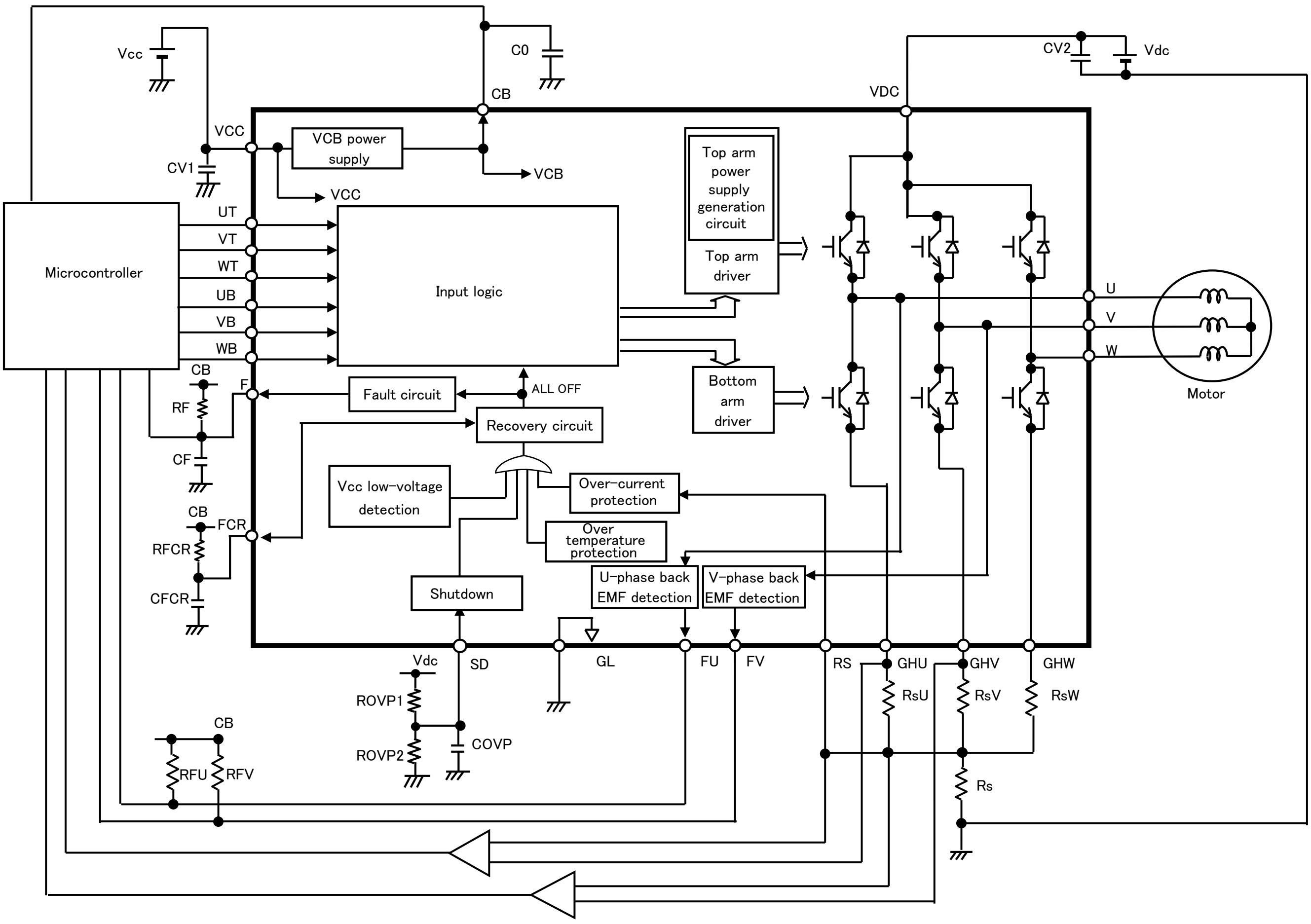


FIGURE 4.1.1 Block Diagram and External Components of IC

Note 1. Caution for smoothing capacitor

As necessary, increase the capacitance and add a zener diode in consideration of noise immunity. Mount each of the components close to the pins of the IC.

Note 2. Section 3.5.1 (2) (b) shows how to set the resistance value.
Note 3. Section 3.5.1 (4) shows how to set the resistance value.
Note 4. When influence of noise or others is large, adjust the capacitance of the capacitor as necessary.

4.2 Other External Components

It is recommended to mount the components shown in Table 4.2.1 to stabilize the power supply and protect the IC from voltage surge.

Adjust the settings of components in accordance with the conditions of use. Moreover, mount each of the components close to the pins of the IC to achieve the effect of the voltage surge absorption.

TABLE 4.2.1 Other External Components

No.	Components	Purpose	Remarks
1	Cvcc1	for VCC. To suppress high frequency noise	Ceramic capacitor with good frequency response, etc. About 1μF
2	Cvcc2	for VCC. To smooth Vcc power supply	Electrolytic capacitor, etc. About 1μF
3	ZDvcc	for VCC. To suppress over voltage	Zener diode with good frequency response
4	VDC	for VDC. To suppress high frequency noise	Ceramic capacitor with good frequency response, etc. About 33nF/630V
		for VDC. To smooth Vdc power supply	Electrolytic capacitor, etc. About 1μF/630V

5. Failure Examples (Assumptions)

5.1 Inverter IC Destruction by External Surge Inputted to Vdc and Vcc Lines (Case 1)

・Cause : An external surge entered the IC on the Vdc and Vcc lines of the motor. Because the Zener voltage of the surge suppressor diode was higher than the maximum rating voltage of the IC, it did not protect the IC.

・Phenomenon : The motor does not rotate due to the over-voltage destruction of the IC.

・Countermeasure : Use a surge suppressor diode with Zener voltage, which is lower than the maximum rating voltage of the IC. The larger the rating capacity of the Zener diode, the more effectively the surge suppressor works.

5.2 Inverter IC Destruction by External Surge Inputted to Vdc and Vcc Lines (Case 2)

・Cause : An external surge entered the IC on the Vdc and Vcc lines of the motor. Because the capacitance of the bypass capacitor for surge suppression was small, the surge could not be sufficiently suppressed.

・Phenomenon : The motor does not rotate due to the over-voltage destruction of the IC.

・Countermeasure : Use the bypass capacitor for surge suppression; its capacity should be enough to suppress surges.

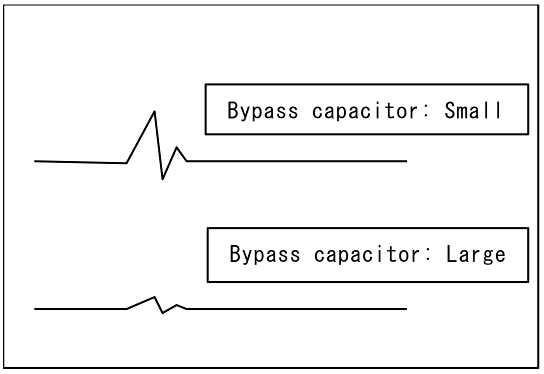


FIGURE 5.2.1 Example of Surge Waveforms for Different Capacitance of Bypass Capacitor

5.3 Inverter IC Destruction by External Surge Inputted to Vdc and Vcc Lines (Case 3)

・Cause : An external surge entered the IC on the Vdc and Vcc lines of the motor. Because the external components for surge suppression were positioned far from the IC on the board, the surge could not be sufficiently suppressed.

・Phenomenon : The motor does not rotate due to the over-voltage destruction of the IC.

・Countermeasure : The bypass capacitor and Zener diode for surge suppression should be mounted close to the IC.

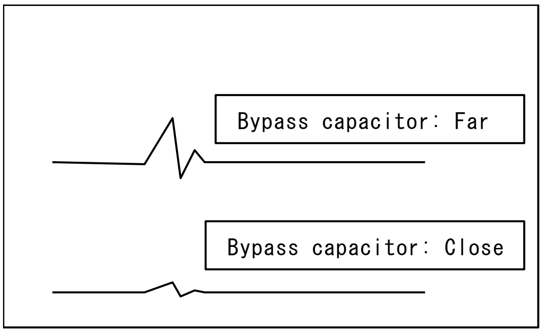


FIGURE 5.3.1 Example of Surge Waveform for Different Bypass Capacitor Locations on the Board

5.4 Inverter IC Destruction by External Surge Inputted to Vcc Line

・Cause : Pulsed noise of a voltage that was lower than the operating voltage of the Vcc low-voltage detection (LVSDON) entered the Vcc line. In this case, the IC repeats split-second LVSD operation. Then the IC has the possibility of overheat breakage.

・Phenomenon : The motor does not rotate due to the destruction of the IC.

・Countermeasure:

① Remove the noise that enters the motor Vcc line by reviewing the power supply circuit (inductance of power cable, noise filter circuit or the like).

② Connect a capacitor having sufficient capacitance close to the VCC pin and GL pin of the IC to absorb noise.

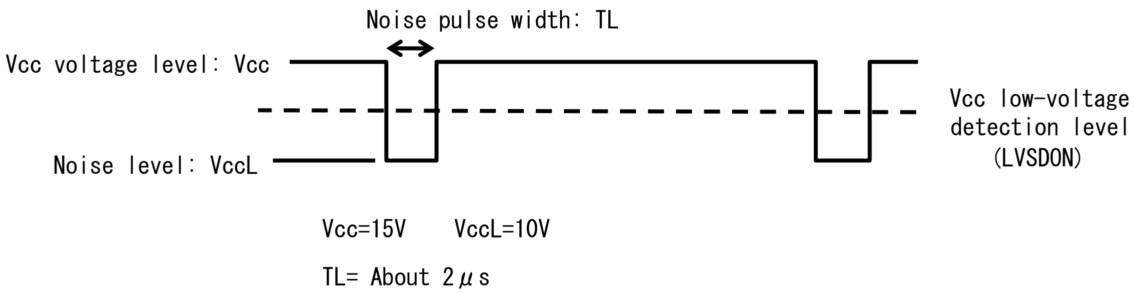


FIGURE 5.4.1 Example of Pulsed Noise on Vcc Line

5.5 Inverter IC Destruction by Vcc Line Noise

・Cause : Surge voltage that exceeded the maximum rating for the IC entered the VCC pin.

・Phenomenon : The motor does not rotate due to the over-voltage destruction of the IC.

・Countermeasure:

① Mount a bypass capacitor C1 near the pin of the IC. Use a capacitor that has excellent frequency characteristics, such as a ceramic capacitor. As a guide, a capacitor of around 1μF is recommended.

② It is more effective to mount a surge suppression device, such as bypass capacitor C2 shown in Fig. 5.5.1, close to the connector of a motor control circuit board.

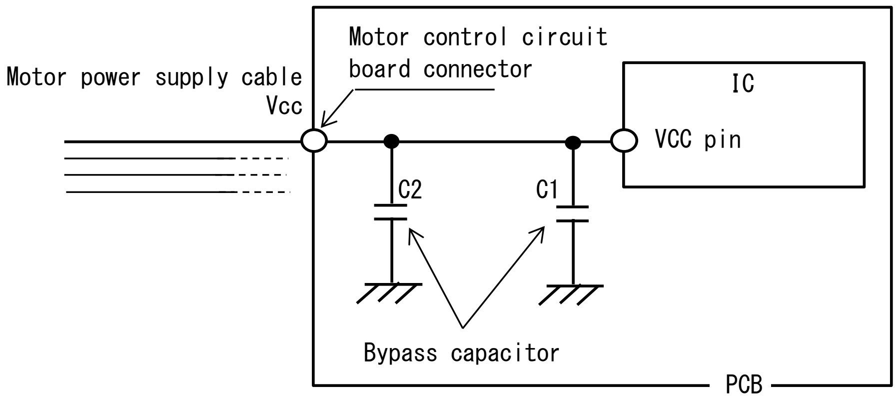


FIGURE 5.5.1 Example of Mounted Surge Suppression Devices

5.6 Inverter IC Destruction by Noise at Vdc Power Supply Power-on

・Cause : Surge voltage that exceeded the maximum rating for the IC entered the VDC pin because the voltage rose suddenly when the Vdc power supply was powered on.

・Phenomenon : The motor does not rotate due to the over-voltage destruction of the IC.

・Countermeasure : Mount a power supply smoothing capacitor near the VDC pin of the IC. An electrolytic capacitor is generally used as a power supply smoothing capacitor.

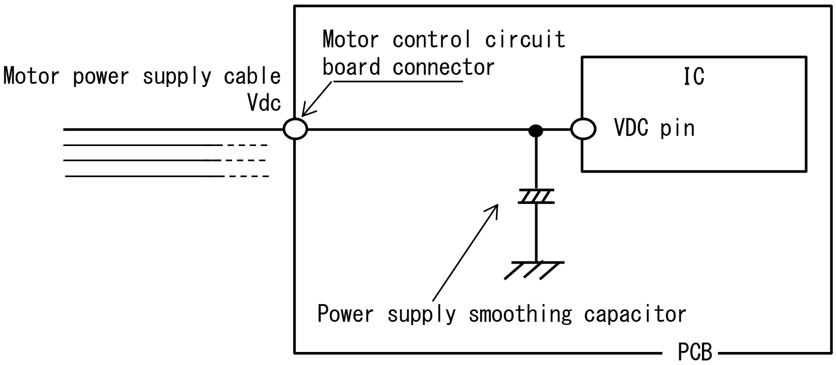


FIGURE 5.6.1 Example of Mounted Power Supply Smoothing Capacitor

5.7 Inverter IC Destruction by Inspection Machine Relay Noise

・Cause : A mechanical relay for on-off control of the electric connection between the IC and an inspection machine generated a surge that entered the IC.

・Phenomenon : The motor does not rotate due to the over-voltage destruction of the IC.

・Countermeasure : Use a mercury relay, etc. Confirm a surge generated when the relay is on-off is less than the maximum rated value.

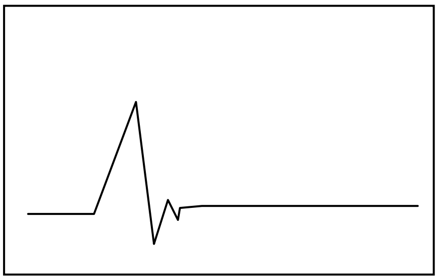


FIGURE 5.7.1 Example of Surge Waveform When Mechanical Relay is Used

5.8 Motor Failure (Missing Phase Output)

・Cause : The motor with missing phase has been out on the market.

・Phenomenon : The motor might start depending on the rotor position when starting even if the motor has missing phase output. Therefore, the missing phase output of motor cannot be detected by the motor rotation test.

・Countermeasure: Monitor the motor current or oscillation in order to detect the missing phase output of motor.

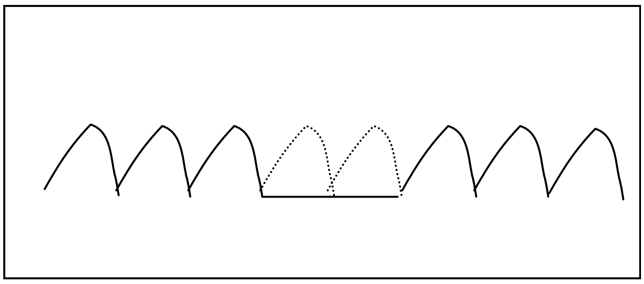


FIGURE 5.8.1 Example of Motor Current Waveform in Phase Missing Condition

6. Precautions for Use

6.1 Countermeasures against Electrostatic Discharge (ESD)

(a) Customers need to take precautions to protect ICs from electrostatic discharge (ESD). The material of the container or any other device used to carry ICs should be free from ESD, which can be caused by vibration during transportation. Use of electrically conductive containers is recommended as an effective countermeasure.

(b) Everything that touches ICs, such as the work platform, machine, measuring equipment, and test equipment, should be grounded.

(c) Workers should be high-impedance grounded (100kΩ to 1MΩ) while working with ICs, to avoid damaging the ICs by ESD.

(d) Friction with other materials, such as high polymers, should be avoided.

(e) When carrying a PCB with a mounted IC, ensure that the electric potential is maintained at a constant level using the short-circuit terminals and that there is no vibration or friction.

(f) The humidity at an assembly line where ICs are mounted on circuit boards should be kept around 45 to 75 percent using humidifiers or such. If the humidity cannot be controlled effectively, using ionized air blowers (ionizers) is effective.

6.2 Storage Conditions (applied to: ECN30625S)

(1) Before opening the moisture prevention bag (aluminum laminate bag)

Temperature: less than 40˚C
Humidity: less than 90%RH
Period: less than 12 months

(2) After opening the moisture prevention bag (aluminum laminate bag)

Temperature: 5˚C to 30˚C
Humidity: less than 60%RH
Period: less than 168 hours

※ When the period of (1) and (2) is likely to expire, store ICs in a drying furnace (10%RH or lower) at ordinary temperature.

(3) Baking process

When the period of (1) and (2) has expired, ICs should be baked in accordance with the following conditions. (However, when ICs are stored in a drying furnace (10%RH or lower) at ordinary temperature, there is no need to bake.)
Do not bake the tape and the reel of the taping package because they are not heat resistant.
Transfer ICs to a heat resistant container prior to baking.

Temperature: 125˚C to 135˚C
Period: more than 48 hours

6.3 Maximum Ratings

Regardless of changes in external conditions during use of IC (the product of Hitachi Power Semiconductor Device, hereinafter called "HPSD's IC"), the "maximum ratings" should never be exceeded when designing electronic circuits that employ HPSD's IC. If maximum ratings are exceeded, HPSD's IC may be damaged or destroyed. In no event shall Hitachi Power Semiconductor Device (hereinafter called "HPSD") be liable for any failure in HPSD's IC or any secondary damage resulting from use at a value exceeding the maximum ratings.

6.4 Derating Design

Continuous high-load operation (high temperatures, high voltages, large currents) should be avoided and derating design should be applied, even within the ranges of the maximum ratings, to ensure reliability.

6.5 Safe Design

The HPSD's IC may fail due to accidents or unexpected surge voltages. Accordingly, adopt safe design features, such as redundancy and measures to prevent misuse, in order to avoid extensive damage in the event of a failure.

6.6 Application

If HPSD's IC is applied to the following uses where high reliability is required, obtain the document of permission from HPSD in advance.

・Automobile, Train, Vessel, etc.

Do not apply HPSD's IC to the following uses where extremely high reliability is required.

・Nuclear power control system, Aerospace instrument, Life-support-related medical equipment, etc.

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